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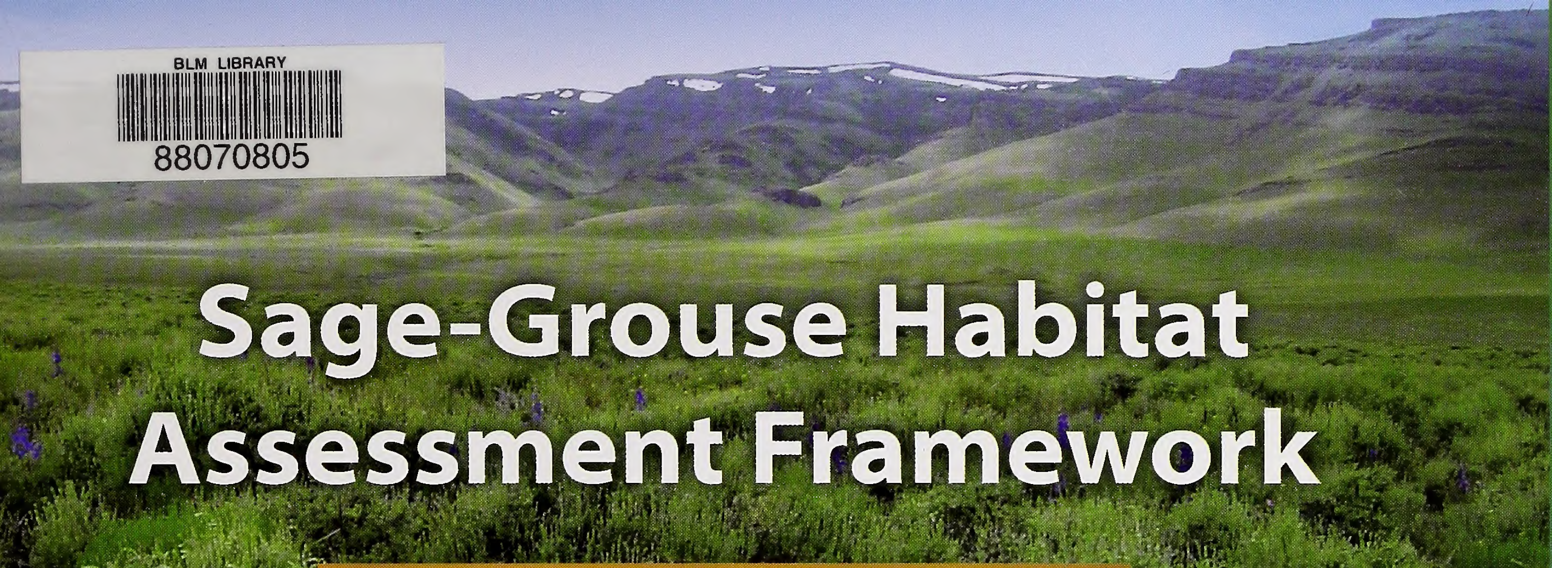
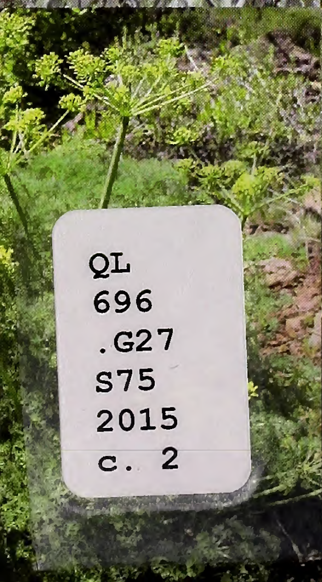
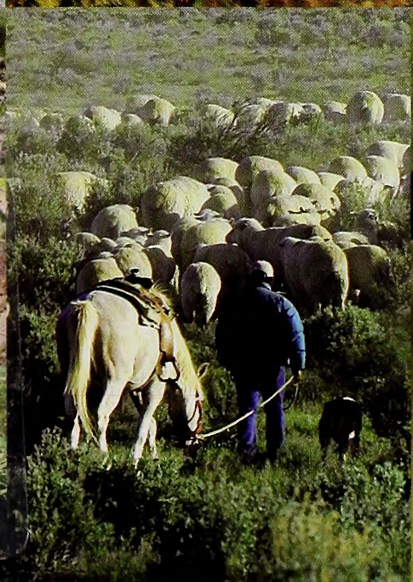


Sage-Grouse Habitat Assessment Framework

A Multiscale Assessment Tool

Technical Reference 6710-1
June 2015





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WAFWA
Western Association of Fish & Wildlife Agencies

National System of Public Lands
U.S. Department of the Interior
Bureau of Land Management

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Errata

Sage-Grouse Habitat Assessment Framework:
A Multiscale Assessment Tool
BLM Technical Reference 6710-1 and Supporting Documents

The following changes have been made to the June 2015 documents posted on the BLM Library website:

Date of change: 7/28/15

Documents affected:

Sage-Grouse Habitat Assessment Framework: A Multiscale Assessment Tool (pdf), page 112

Table of sagebrush community vegetation species and preferred forbs for sage-grouse (pdf), page 4

Table of sagebrush community vegetation species and preferred forbs for sage-grouse (Word), page 6

Change:

In the table, under Perennials/Occasionally Biennials, the most likely category for *Linum perenne* (blue flax) was changed from P to O so that it now reads:

Linum perenne	Blue flax	LIPE2	O

Date of change: 8/24/15

Documents affected:

Sage-Grouse Habitat Assessment Framework: A Multiscale Assessment Tool (pdf), page 91

Line-Point Intercept Directions, page 1

Change:

In the list of equipment, the length of the tape was changed from 5 m to 50 m.

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Sage-Grouse Habitat Assessment Framework

A Multiscale Assessment Tool

Technical Reference 6710-1

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June 2015

Suggested citation:

Stiver, S.J., E.T. Rinkes, D.E. Naugle, P.D. Makela, D.A. Nance, and J.W. Karl, eds. 2015. Sage-Grouse Habitat Assessment Framework: A Multiscale Assessment Tool. Technical Reference 6710-1. Bureau of Land Management and Western Association of Fish and Wildlife Agencies, Denver, Colorado.

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Paul Makela, Tom Rinkes, and Bureau of Land Management (stock photos).

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BLM/OC/ST-15/002+6710

Foreword

The "Sage-Grouse Habitat Assessment Framework" (HAF) was conceived by several managers in the early 2000s. They assembled a diverse group of habitat specialists and sage-grouse experts from state, federal, and nongovernmental organizations to develop this habitat evaluation tool. In 2006, the "Greater Sage-grouse Comprehensive Conservation Strategy," published by the Western Association of Fish and Wildlife Agencies, highlighted the development and implementation of the HAF. That strategy outlined a number of objectives for the HAF, which included a temporal and spatial method for evaluating sagebrush habitats for sage-grouse suitability at various landscape scales. The HAF is a cornerstone of the habitat monitoring component of the sage-grouse conservation strategy.

Over the past several years, the BLM has developed a number of tools to help manage the public lands on a landscape basis. These tools include creating the capacity to synthesize large amounts of geospatial information to help the BLM and our partners develop a shared understanding of regional trends and identify conservation and development opportunities. The BLM is implementing this landscape approach in the Greater Sage-Grouse planning initiative, western solar plan, national cohesive wildland fire strategy, climate change strategy, regional mitigation, and other major initiatives. Incorporating the necessary adaptive management actions and understanding the success of these initiatives will require a coordinated approach to monitoring and assessments so information about multiple resources at multiple scales can be easily integrated. Thus, the HAF is timely as it fills the need for a multiple-scale, sage-grouse habitat assessment tool that can be easily integrated into the BLM landscape monitoring approach.

The HAF establishes indicators to determine the status of sage-grouse habitat needs at multiple scales and for seasonal habitats. The results of these assessments will provide the necessary information to evaluate whether the BLM-managed lands are meeting the sage-grouse land health habitat standard. Since the HAF assesses habitat needs at multiple scales, various datasets are needed for the analysis and assessment. To this end, the editors of the HAF coordinated with the BLM assessment, inventory, and monitoring (AIM) team to ensure the data required for the HAF indicator values are consistent with information currently being collected as described in "BLM Core Terrestrial Indicators and Methods," Westwide monitoring efforts, and grass-shrub stewardship efforts. This coordination between HAF and AIM efforts addresses one of the critical monitoring challenges in the BLM today—field capacity to complete the monitoring data collection.

To assess monitoring capacity and propose options to resolve this issue, the BLM initiated a review of its monitoring practices in 2006. The results of this survey, as discussed in "The Bureau of Land Management Assessment, Inventory, and Monitoring Strategy for Integrated Renewable Resources Management," indicated the need to coordinate and integrate monitoring activities and implement a data management strategy to eliminate redundant and duplicative data collection activities. The principles necessary to accomplish this integrated monitoring approach are described in BLM's "AIM-Monitoring: A Component of the BLM Assessment, Inventory, and Monitoring Strategy." When applying the principles of AIM monitoring to the HAF, field offices can minimize additional monitoring workloads. Applying these principles also creates opportunities to enhance national data layers and meet one of our primary goals of integrating monitoring activities: to collect data once and use it many times.

In summary, we commend the effort that has led to the development of the "Sage-Grouse Habitat Assessment Framework." The HAF will prove to be a valuable tool as the BLM and our partners implement the landscape approach for the management of our public lands. When the HAF is implemented using the principles outlined in "AIM-Monitoring: A Component of the BLM Assessment, Inventory, and Monitoring Strategy," the benefits to the BLM and our partners will be maximized and additional workloads will be minimized.

Ed Roberson

Ed Roberson
Assistant Director, Renewable Resources and Planning
Bureau of Land Management

Virgil Moore

Virgil Moore
Director
Western Association of Fish and Wildlife Agencies

Preface

This document provides policymakers, resource managers, and specialists with a comprehensive framework for assessing sage-grouse habitat in the sagebrush ecosystem. Four pillars form the foundation for the success of this approach: science, effective conservation policy, implementation, and adaptive management. Recent landscape evaluations indicate that conservation of sagebrush ecosystems has not been realized because large-scale mapping was not available to inform site-scale management actions. Advances in landscape ecology enable conservation planners to develop spatially explicit decision support tools that link populations with habitats for effective conservation planning, implementation, and evaluation at landscape scales. A shift from local to landscape conservation will empower decisionmakers to maximize the likelihood of achieving conservation by implementing site-scale actions within priority landscapes. Standardized methodologies provide consistency in terminology and techniques for site-scale assessments.

The habitat assessment framework (HAF) received progressive reviews during its development from 2000 to 2012. Those reviews focused and refocused the scope of the document, technical validity, and scientific rigor. The draft was edited for field use, and an outside peer review panel was contracted to evaluate the document. Appropriate comments, critiques, and suggestions were incorporated into the final document. In 2011, 2012, and 2013, the input matrix and outputs were field tested, and appropriate modifications were made in this current iteration of the HAF.

The HAF was developed for use by resource managers working closely with specialists in range management, landscape ecology, geographic information system (GIS), botany, wildlife biology, and other associated disciplines. To be fully functional, the HAF requires input from policy and operational staff. Some flexibility is incorporated into the suggested procedures, where appropriate, and professional judgment is required in its application, hence the need for experience. An increased capacity to deliver conservation will need to be addressed regionally because actions necessary to enhance populations vary widely across management zones. Quantity and quality of population and distribution data also vary widely for individual populations and across management zones; therefore, users of the HAF may be required to make certain assumptions concerning local populations. Shortcomings in existing datasets highlight the need to identify and subsequently collect additional datasets. Datasets that may aid in identifying important habitat areas and features include population and habitat information on seasonal use patterns, home ranges, migratory and dispersal movements, and fitness.

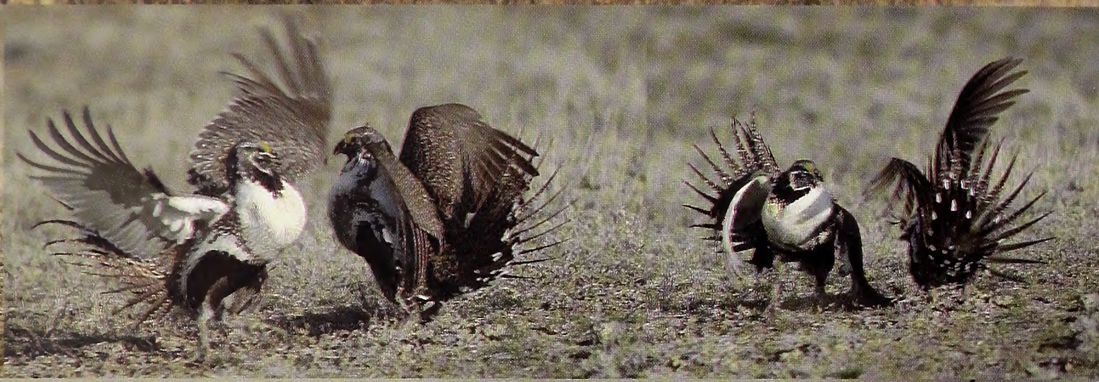
Acknowledgments

The habitat assessment framework is the culmination of many years of collaborative efforts. The editors participated in many of these efforts and would like to express our deep appreciation to the great number of individuals who helped develop this framework and who contributed to this document. This document would not have been possible without the forethought of Signe Sather-Blair, who led a group of Bureau of Land Management (BLM) wildlife biologists in Idaho (Paul Makela, Tim Carrigan, and Loren Anderson) in drafting the initial site-scale analysis methodology of this habitat assessment in 2000. A year later, the BLM revised the site-scale methodology to be applicable for habitats in Wyoming. George Soehn led this effort, with input from an interdisciplinary team that included Vicki Herren, Pat Karbs, Bruce Parker, Mary Read, Tom Rinkes, Dave Roberts, Dennis Saville, Andy Warren, Chet Wheeless, Don Whyde, and Jim Wolf.

In 2004, following the release of the "Conservation Assessment of Greater Sage-grouse and Sagebrush Habitats," the need to assess habitats at multiple scales became apparent because sage-grouse use large landscapes and occur over a large geographical range in western North America. In January 2005, the directors of the Western Association of Fish and Wildlife Agencies (WAFWA) passed a resolution to coordinate with the BLM on the development of the sage-grouse habitat assessment framework. Again, Signe Sather-Blair brought together a team composed of BLM and Idaho Department of Fish and Game biologists (Michelle Commons-Kemner, Tom Rinkes, and Alexis Carroll) to address sage-grouse at multiple habitat scales. An informal working group, with members from various disciplines, federal and state agencies, and universities, was convened to assist in addressing these issues, and their comments were valuable in the development of the final product. This working group was composed of the following individuals:

Cameron Aldridge, Colorado State University
Anthony Apa, Colorado Division of Wildlife
Alexis Carroll, BLM
Michelle Commons-Kemner, Idaho Department of Fish and Game
Jack Connelly, Idaho Department of Fish and Game
Mike Gregg, U.S. Fish and Wildlife Service
Kristine Hasselblad, BLM
Ann Hild, University of Wyoming
Mark Hilliard, BLM
Mike "Sherm" Karl, BLM
Steve Knick, U.S. Geological Survey
Don Major, BLM
Dick Mayberry, BLM
Clint McCarthy, U.S. Forest Service
Richard Miller, Oregon State University
Dave Naugle, University of Montana
Mike Pellant, BLM
Tom Rinkes, BLM
Roger Rosentreter, BLM
Paul Roush, BLM
Signe Sather-Blair, BLM
Pat Shaver, Natural Resources Conservation Service
Jim Sedinger, University of Nevada, Reno

Others who provided valuable insight and comments during the development of this document include Brendan Moynahan, Mary Rowland, Cal McCluskey, Danielle Flynn, Barry Rose, Alan Sands, Jason Sutter, Susan Filkins, Paul Makela, Sarah McCord, and WAFWA's Western States Sage and Columbian Sharp-tailed Grouse Technical Committee (Tom Hemker, Christian Hagen, Joe Bohne, Shawn Espinosa, and Rick Northrup). Roger Rosentreter and Alan Sands significantly updated the list of forb species used by sage-grouse. Michael Schroeder, Fee Busby, Greg Neudecker, and David Pyke provided suggestions for improving the document in its final stages. Additional reviews and comments were incorporated by the BLM's Washington Office Resources and Planning staff and the BLM's National Operations Center staff.



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Chapter I: Conceptual Overview

Introduction

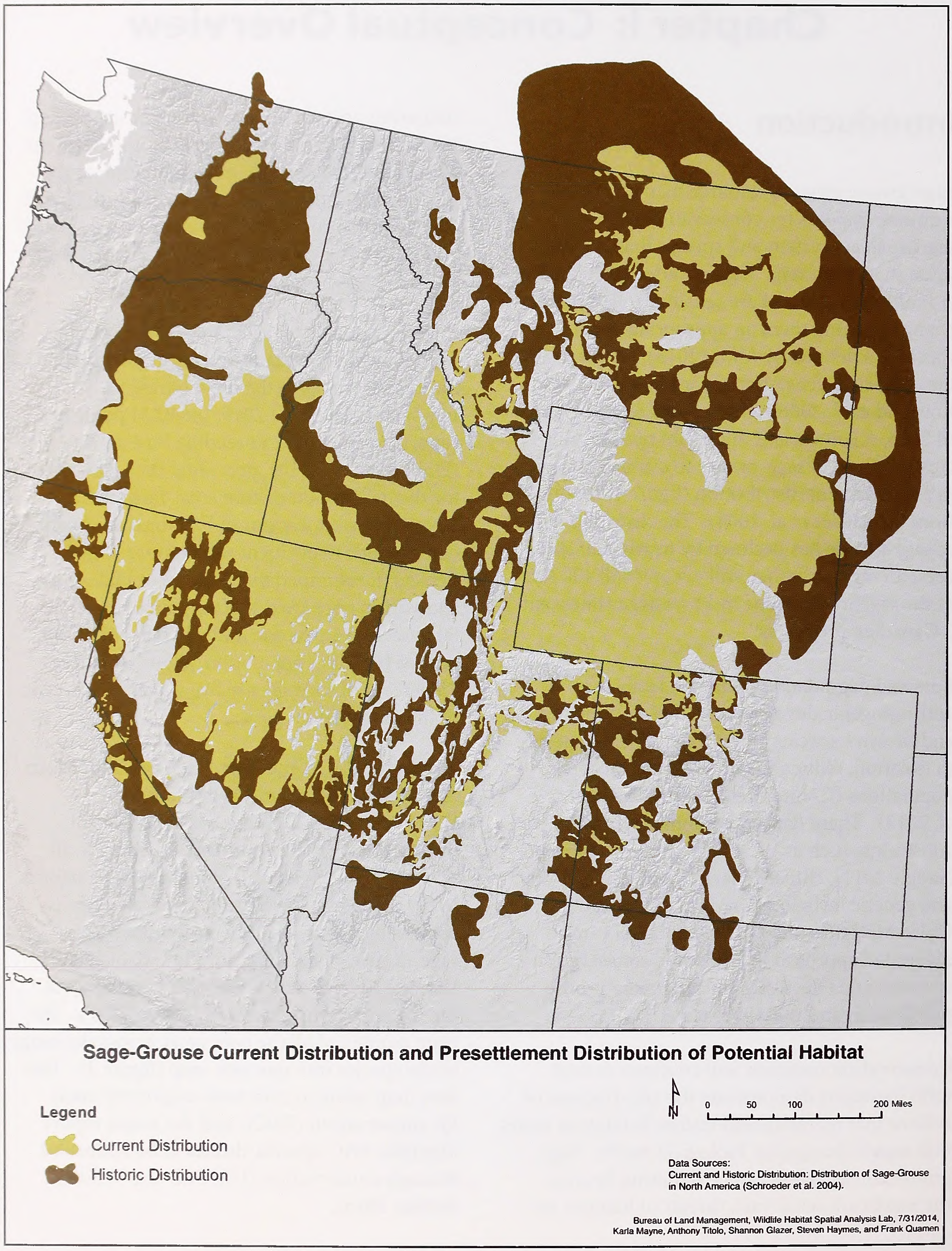
Sage-grouse provide resource managers with a unique impetus for conservation of the sagebrush ecosystem and species that depend upon that ecosystem. Sage-grouse select habitat at multiple scales and are sensitive to landscape change, making them an appropriate focal species, as defined by Mills (2013), for managing the sagebrush ecosystem (Wisdom et al. 2005; Rowland et al. 2006b; Hanser and Knick 2011). In 2004, scientists and managers remapped the current range of sage-grouse to evaluate change in presettlement distribution (figure 1; modified from Schroeder et al. 2004). The distribution of sage-grouse has declined by nearly half since presettlement, but they still occupy 668,400 km^2 of the sagebrush steppe in 11 western states and 2 Canadian provinces.

Loss and degradation of habitat from anthropogenic developments, fire, sodbusting, and invasive species are primary threats leading to isolation, reduction, and extirpation of populations (Connelly et al. 2000; Knick et al. 2013). These factors, combined with new constraints such as West Nile virus (Walker and Naugle 2011), climate change (Nielson et al. 2005) and genetic isolation (Knick and Hanser 2011; Oyler-McCance and Quinn 2011), require an integrated approach to landscape conservation to assess and effectively conserve sage-grouse populations and their habitats.

Conservation concerns will continue to exist until managers demonstrate the effectiveness of actions that maintain and restore habitats at scales that match the species' biological needs. Sage-grouse conservation can be daunting because the sagebrush sea is vast, threats to habitats are numerous and varied, and resources are limited. Maximizing return on conservation investment by targeting policy and implementation to the most biologically important places (Bottrill et al. 2008) for this conservation-reliant species (Scott et al. 2010) is a proactive yet fundamental shift occurring in management philosophy.

Policymakers and practitioners alike are now using broad-scale planning tools to help guide limited resources to the most biologically important places. In 2010, the BLM published a report that included a breeding bird density map (Doherty et al. 2010), providing the foundation for the delineation of core areas rangewide. Core areas are locations of high bird abundance containing a majority of sage-grouse. Figure 2 depicts the clumped distribution of males on leks within core areas that contain 25 percent, 50 percent, 75 percent, and 100 percent of the known breeding population. Approximately 75 percent of sage-grouse live within 25 percent of the occupied range.

Through time, 11 member states of the Western Association of Fish and Wildlife Agencies (WAFWA) improved the core area concept by delineating their boundaries to include all seasonal habitats instead of just breeding habitat. Many western states have incorporated newly approved core areas in their own state-based sage-grouse plans. In 2013, the U.S. Fish and Wildlife Service partnered with states to form the Conservation Objectives Team (COT). The team combined all the core areas across the range of the species into one new map (figure 3). This new map refers to core areas as priority areas for conservation (PACs) and the team's report identifies PAC-specific threats to be addressed through conservation (U.S. Fish and Wildlife Service 2013).



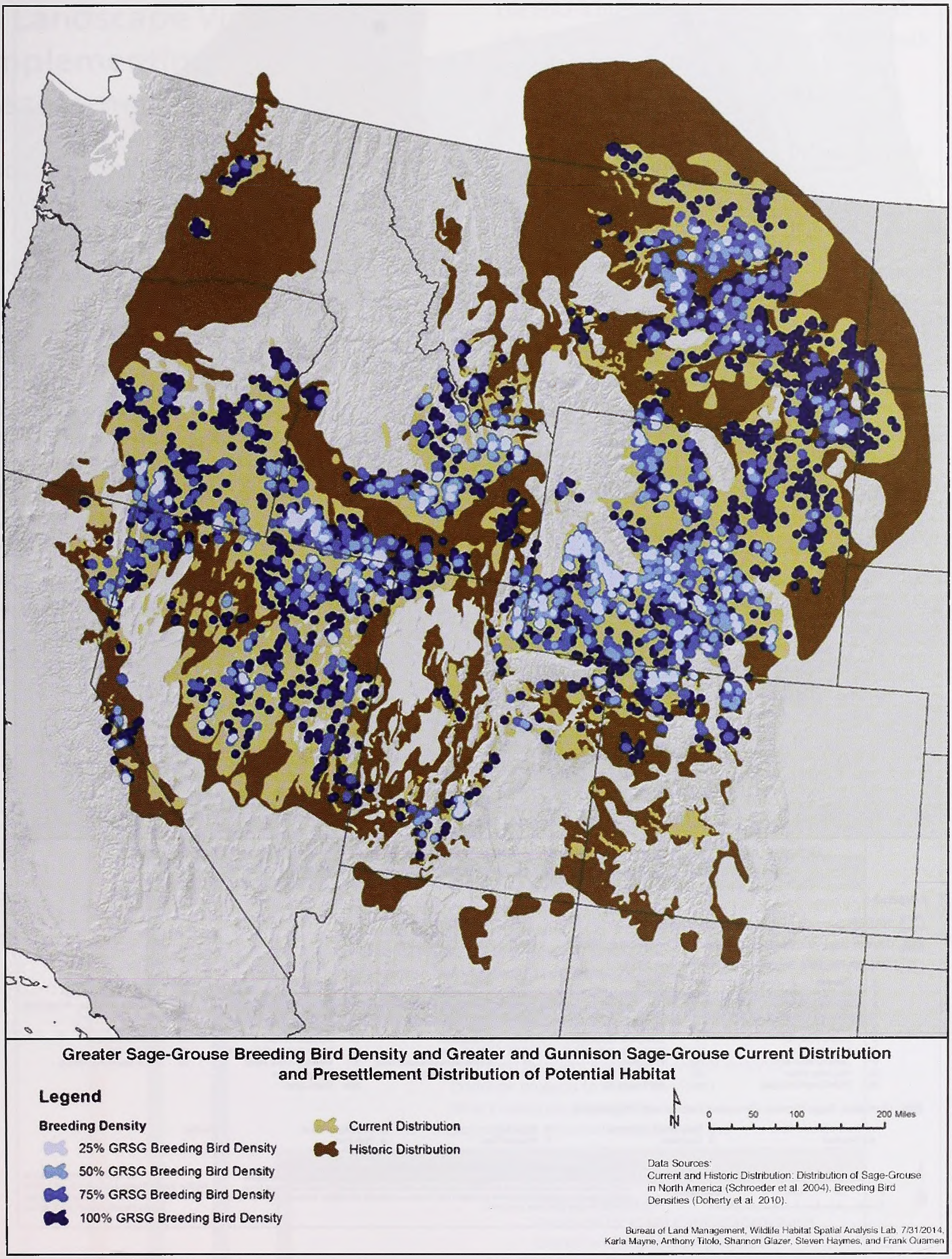
Sage-Grouse Current Distribution and Presettlement Distribution of Potential Habitat

Legend
Current Distribution
Historic Distribution
N
0
50
100
200 Miles

Data Sources:
Current and Historic Distribution: Distribution of Sage-Grouse in North America (Schroeder et al. 2004).

Bureau of Land Management, Wildlife Habitat Spatial Analysis Lab, 7/31/2014, Karla Mayne, Anthony Titolo, Shannon Glazer, Steven Haymes, and Frank Quamen

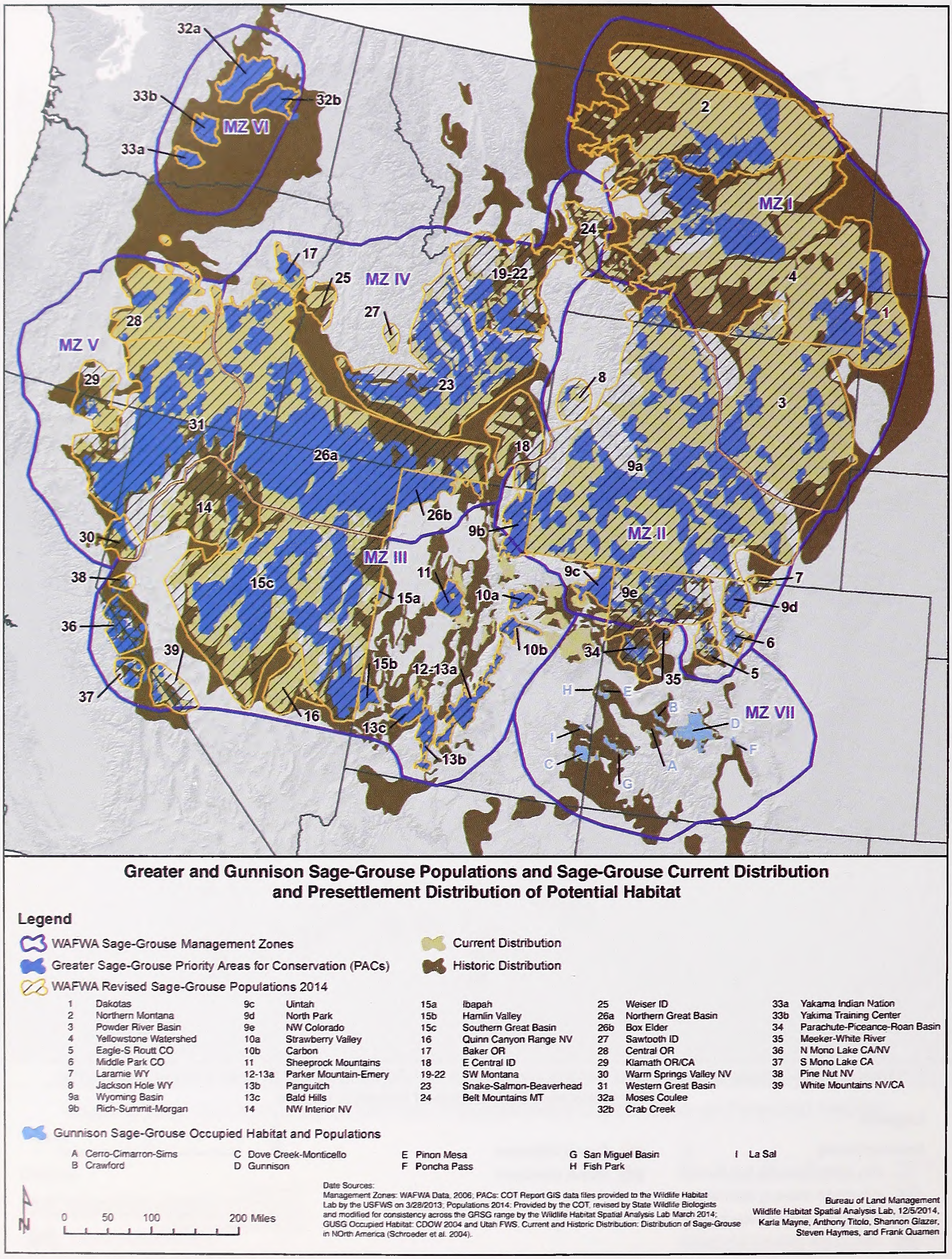
Figure 1. Current distribution and presettlement distribution of potential habitat of Greater and Gunnison Sage-Grouse in North America (as modified from Schroeder et al. 2004).


Greater Sage-Grouse Breeding Bird Density and Greater and Gunnison Sage-Grouse Current Distribution and Presettlement Distribution of Potential Habitat
Legend
Breeding Density
25% GRSG Breeding Bird Density
50% GRSG Breeding Bird Density
75% GRSG Breeding Bird Density
100% GRSG Breeding Bird Density
Current Distribution
Historic Distribution
N
0
50
100
200 Miles

Data Sources:
Current and Historic Distribution: Distribution of Sage-Grouse in North America (Schroeder et al. 2004), Breeding Bird Densities (Doherty et al. 2010).

Bureau of Land Management, Wildlife Habitat Spatial Analysis Lab, 7/31/2014, Karla Mayne, Anthony Titolo, Shannon Glazer, Steven Haymes, and Frank Quamen

Figure 2. Greater Sage-Grouse (GRSG) population centers or "core areas" across the species' range. The lightest blue areas contain 25 percent of the breeding population, and each darker shade of blue indicates an additional 25 percent. Gunnison Sage-Grouse breeding bird density is not displayed.


32a
33b
32b
MZ VI
33a
17
25
MZ IV
27
19-22
24
2
MZ I
4
1
28
MZ V
29
23
8
3
31
26a
18
9a
14
26b
9b
MZ II
30
MZ III
11
9c
7
38
15c
15a
10a
9e
9d
36
10b
6
39
15b
12-13a
34
5
35
37
16
H
E
B
MZ VII
13c
D
I
A
F
C
13b
G
Greater and Gunnison Sage-Grouse Populations and Sage-Grouse Current Distribution and Presettlement Distribution of Potential Habitat
Legend
WAFWA Sage-Grouse Management Zones
Greater Sage-Grouse Priority Areas for Conservation (PACs)
WAFWA Revised Sage-Grouse Populations 2014
Current Distribution
Historic Distribution
1 Dakotas
2 Northern Montana
3 Powder River Basin
4 Yellowstone Watershed
5 Eagle-S Routt CO
6 Middle Park CO
7 Laramie WY
8 Jackson Hole WY
9a Wyoming Basin
9b Rich-Summit-Morgan
9c Uintah
9d North Park
9e NW Colorado
10a Strawberry Valley
10b Carbon
11 Sheeprock Mountains
12-13a Parker Mountain-Emery
13b Panguitch
13c Bald Hills
14 NW Interior NV
15a Ibapah
15b Hamlin Valley
15c Southern Great Basin
16 Quinn Canyon Range NV
17 Baker OR
18 E Central ID
19-22 SW Montana
23 Snake-Salmon-Beaverhead
24 Belt Mountains MT
25 Weiser ID
26a Northern Great Basin
26b Box Elder
27 Sawtooth ID
28 Central OR
29 Klamath OR/CA
30 Warm Springs Valley NV
31 Western Great Basin
32a Moses Coulee
32b Crab Creek
33a Yakama Indian Nation
33b Yakima Training Center
34 Parachute-Piceance-Roan Basin
35 Meeker-White River
36 N Mono Lake CA/NV
37 S Mono Lake CA
38 Pine Nut NV
39 White Mountains NV/CA
Gunnison Sage-Grouse Occupied Habitat and Populations
A Cerro-Cimarron-Sims
B Crawford
C Dove Creek-Monticello
D Gunnison
E Pinon Mesa
F Poncha Pass
G San Miguel Basin
H Fish Park
I La Sal
N
0 50 100 200 Miles

Date Sources:
Management Zones: WAFWA Data, 2006; PACs: COT Report GIS data files provided to the Wildlife Habitat Lab by the USFWS on 3/28/2013; Populations 2014: Provided by the COT, revised by State Wildlife Biologists and modified for consistency across the GRSG range by the Wildlife Habitat Spatial Analysis Lab March 2014; GUSG Occupied Habitat: CDOW 2004 and Utah FWS. Current and Historic Distribution: Distribution of Sage-Grouse in NOrth America (Schroeder et al. 2004).

Bureau of Land Management
Wildlife Habitat Spatial Analysis Lab, 12/5/2014,
Karla Mayne, Anthony Titolo, Shannon Glazer,
Steven Haymes, and Frank Quamen

Figure 3. Priority areas for conservation (PACs) as identified by the Conservation Objectives Team (COT) and Gunnison Sage-Grouse occupied habitats. PACs are encircled by seven sage-grouse management zones established by the Western Association of Fish and Wildlife Agencies (WAFWA) based on populations within floristic provinces (Stiver et al. 2006).

A Landscape Vision for Implementing the Habitat Assessment Framework

Incorporating Scale into Sage-Grouse Policy and Implementation

The vision for this habitat assessment framework (HAF) is to empower managers to implement project-level actions that make sense at landscape scales. To achieve this vision, the HAF addresses two primary subjects: (1) applying the hierarchy for implementing landscape conservation, and (2) providing the inventory and outcome-based evaluation tools necessary for assessing effectiveness of resulting conservation actions. Sage-grouse habitats transcend jurisdictional boundaries and therefore require a coordinated approach to management. The HAF provides a blueprint for landscape conservation; success will be achieved through implementation with local stakeholder involvement.

The HAF's hierarchical approach begins with a policy vision for management of the sagebrush ecosystem (figure 4). Such policy changes are underway at federal and state levels in collaboration with major land users and the public. Emerging policies vary by agency and state, but all aim to reduce threats to sage-grouse by reducing disturbance and implementing beneficial actions primarily inside PACs. New policy direction and resources at the broad scale facilitate conservation and empower state and regional managers.

At the second level in the hierarchy, state and regional managers design the future landscape through mid-scale policy direction aimed at reducing specific threats facing sage-grouse in their jurisdiction. Threats vary geographically, but generally, policy will include actions to protect, manage, and restore seasonal habitats and to maintain connectivity of pathways that facilitate movement within and among populations. State and regional decisionmakers fulfill their place in the hierarchy by providing

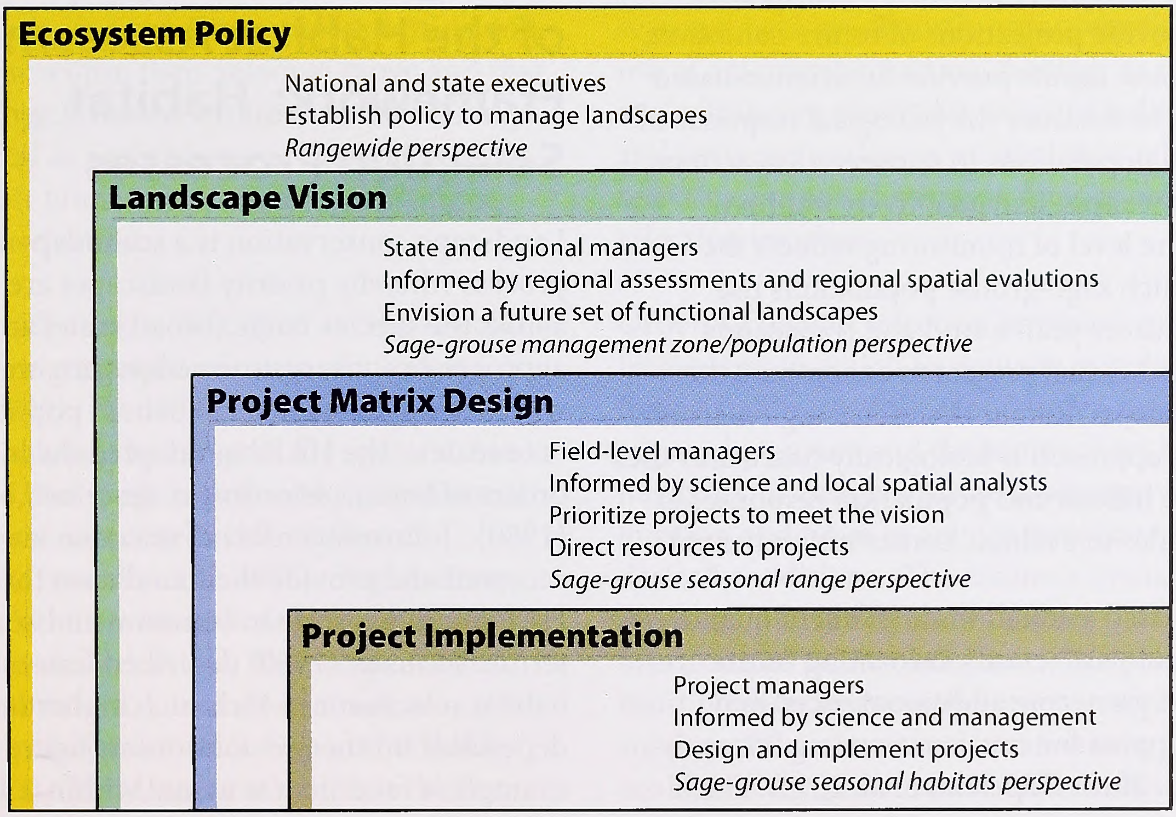

Ecosystem Policy
National and state executives
Establish policy to manage landscapes
Rangewide perspective
Landscape Vision
State and regional managers
Informed by regional assessments and regional spatial evalutions
Envision a future set of functional landscapes
Sage-grouse management zone/population perspective
Project Matrix Design
Field-level managers
Informed by science and local spatial analysts
Prioritize projects to meet the vision
Direct resources to projects
Sage-grouse seasonal range perspective
Project Implementation
Project managers
Informed by science and management
Design and implement projects
Sage-grouse seasonal habitats perspective

Figure 4. A hierarchical approach for implementing the habitat assessment framework.

their field managers with direction and resources to meet the landscape vision.

At the third level in the hierarchy, field managers design a matrix of fine-scale conservation actions that satisfy state and regional directives. Field managers develop specific actions and prioritize them by importance, timing for implementation, and cost. Field managers fulfill their place in the hierarchy by providing project managers with project implementation priorities.

At the fourth and equally important level in the hierarchy, project managers implement the specified site-scale conservation actions. Implementing the right actions in the right places at biologically relevant scales is the key to conserving and restoring the sagebrush ecosystem. Successfully implementing the HAF will initiate and foster a new era in landscape conservation of the sagebrush ecosystem.

Integrating Science into Habitat Assessment Framework Implementation

Inventory and monitoring are integral components of the HAF. Inventory provides baseline data and may provide projections of future condition. Together, these inputs provide for science-based evaluations to measure the biological response of sage-grouse populations to conservation actions, assess effectiveness, and adaptively improve delivery. The level of monitoring reflects the scales at which sage-grouse populations use habitat resources year-round and transcends that of an individual project to encompass the larger landscape. Rather than focusing on acres treated, the approach is biologically based and uses sage-grouse habitat and population responses at multiple scales to evaluate conservation benefits.

Outcome-based evaluations are vital to quantifying the success of past actions, informing future actions, and garnering additional social and financial support for conservation (e.g., Baruch-Mordo et al. 2013; Copeland et al. 2013). Such evaluations are a primary tool for applying effective adaptive management strategies in conservation and fulfilling the commitments in the "Greater Sage-Grouse Comprehensive Conservation Strategy" (Stiver et al. 2006) and the "Gunnison Sage-Grouse Rangewide Conservation Plan" (Gunnison Sage-Grouse Rangewide Steering Committee 2005). Shortcomings in existing datasets highlight the need to identify and subsequently collect additional information, including population and habitat information. For example, the HAF will be instrumental in assessing the effectiveness of a new management approach being implemented by the BLM Fire and Invasives Assessment Team (FIAT). The new management approach uses existing data to map soil temperature and moisture regimes along with the amount of sagebrush cover across landscapes to predict a sagebrush ecosystem's resilience to disturbance and resistance to invasive species (Chambers et al. 2013; Sage Grouse Initiative 2014). This tool helps prioritize and pinpoint management tactics across sagebrush landscapes, from fire and fuels management to restoration, and partners have already quickly engaged in implementation of this new strategic approach.

Biological Underpinnings of the Habitat Assessment Framework: Habitat Selection Processes

Landscape conservation is a scale-dependent process whereby priority landscapes are identified across the species range (broad scale) and appropriate conservation actions are implemented within seasonal habitats to benefit populations (site scale). The HAF has adopted the hierarchical orders of habitat selection as described by Johnson (1980). Johnson's orders of selection are widely accepted and provide the foundation for the HAF to discuss scale in common and consistent terms. Johnson (1980) described four orders of habitat selection in which each higher order is dependent on the previous order (figure 5). For example, a food item is nested within a feeding site, which is nested within a seasonal use area, which is nested within a home range, which is

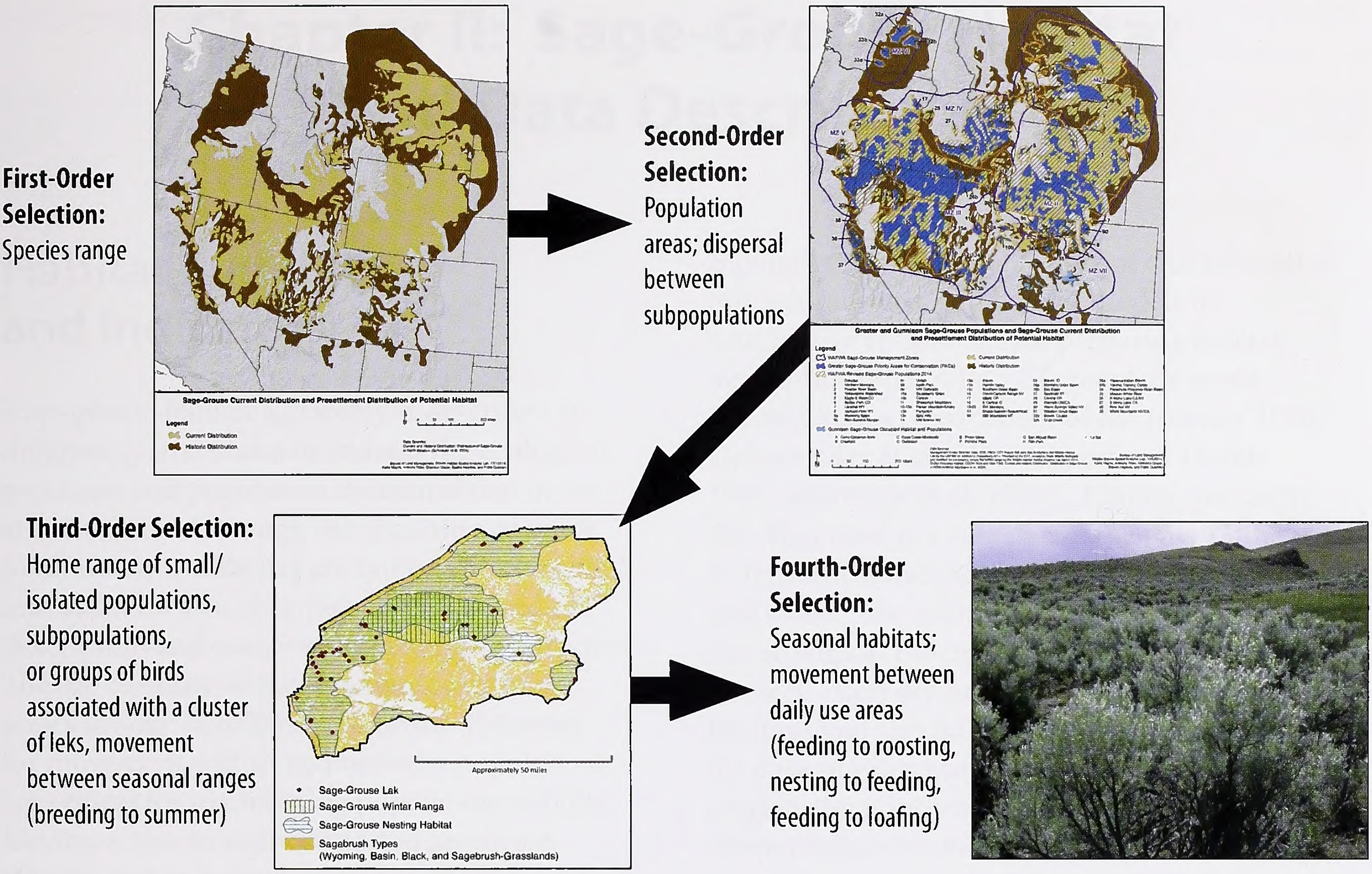

First-Order Selection: Species range
Sage-Grouse Current Distribution and Presettlement Distribution of Potential Habitat
Legend
Current Distribution
Historic Distribution
Second-Order Selection: Population areas; dispersal between subpopulations
Greater and Gunnison Sage-Grouse Populations and Sage-Grouse Current Distribution and Presettlement Distribution of Potential Habitat
MZ IV
MZ V
MZ VII
Third-Order Selection: Home range of small/isolated populations, subpopulations, or groups of birds associated with a cluster of leks, movement between seasonal ranges (breeding to summer)
Approximately 50 miles
Sage-Grouse Lek
Sage-Grouse Winter Range
Sage-Grouse Nesting Habitat
Sagebrush Types (Wyoming, Basin, Black, and Sagebrush-Grasslands)
Fourth-Order Selection: Seasonal habitats; movement between daily use areas (feeding to roosting, nesting to feeding, feeding to loafing)

Figure 5. Habitat selection by sage-grouse based on Johnson's (1980) four orders.

nested within a population area, which is part of the species range. Sage-grouse select nesting and feeding areas within their seasonal range and that seasonal range is nested within their home range. An ecological or anthropogenic disturbance that changes their home range can affect nesting or feeding site selection.

First-order selection is described as "the selection of physical or geographical range of a species" (Johnson 1980). By definition, there is only one first-order habitat, the range of the species. For sage-grouse, the range is defined by populations of sage-grouse associated with sagebrush landscapes (Connelly et al. 2003). Populations or subpopulations within those populations are the second-order selection. The second-order selection habitats may include as many as 39 discrete populations (U.S. Fish and Wildlife Service 2013). Third-order selection is the home range of an individual bird. Location and size of a home range is determined in part by the quality and juxtaposition of resources within and between seasonal habitats. Fourth-order selection is the use of a particular nesting, feeding, or roosting site within one particular seasonal habitat. Spatial and temporal scales are evident throughout the selection process, becoming finer as orders of selection increase.

Orders of habitat selection provide a unifying framework in which to evaluate populations and their habitats. At the second order, state and regional planners and decisionmakers have the flexibility to design a future landscape and the location and types of actions necessary to achieve desired conditions. The resource manager has significant flexibility in evaluating third- and fourth-order habitat selection. The manager must provide an accurate estimate of populations, subpopulations, seasonal-use habitats, and ecological site potentials to effectively coordinate and design appropriate conservation actions.

Chapter II: Sage-Grouse Habitat and Data Descriptions

Habitat Suitability and Indicators

Sage-grouse habitat suitability is described at different spatial scales to address the ecological processes and population dynamics that occur at each scale. Although life requisites of space, food, water, and shelter are not easily segmented into spatial scales, they must be addressed for description and conservation planning purposes. The life requisite of space is significant at all scales though in different contexts. Pathways for movement within and between populations are critical for maintaining population viability. Having access to well-connected sagebrush patches that provide dispersal and movement among subpopulations is essential for sage-grouse population viability and persistence over the long term. However, a variety of natural or anthropogenic disturbances may interrupt or retard dispersal. Similarly, at the fine scale, habitat availability, security, and connectivity within home ranges are important for securing seasonal movements to shelter and food needs. Shelter and food availability at the site-scale within the seasonal ranges directly affects individual fitness, survival, and reproductive potential. Thus, the suitability of habitat at each scale has significant conservation implications on population health.

Biologists use measurable habitat characteristics, procedural steps, and habitat models to standardize techniques for preparing habitat descriptions that reflect life requisite needs (United States Department of the Interior 1980; Cooperrider et al. 1986; Gilbert and Dodds 1987; Morrison et al. 1998). Habitat indicators are often used to characterize the environment in terms of suitability for shelter, food, water, and space. The indicators must be sensitive to the ecological processes operating at the scale of interest. They are based on scientific research findings and should be quantitatively repeatable for data summarization and to avoid bias. A single habitat indicator does not necessarily define habitat suitability for an area or particular scale. Once measured or described, indicators must be collectively reviewed and put into context to correctly determine habitat suitability. In many cases, more than one scale with multiple indicators will be of interest. This chapter describes the important habitat indicators for each scale (table 1) and considerations for integrating information for within- and between-scale habitat descriptions. Habitat indicators for the mid and fine scales are generally evaluated based on trends of each of the scale indicators. Habitat indicators for the site scale are generally compared from the range, mean, proximity, shape, and stability of the various seasonal habitat components.

Table 1. Summary of habitat suitability indicators and descriptions for the mid, fine, and site scales. Suitability descriptions appropriate for each scale are based on the habitat indicator measurements for that scale.

Mid-Scale (Second-Order) Descriptions – Isolated/small population, subpopulation, or home range of group of leks	
Habitat Indicators	1. Habitat Availability 2. Patch Size and Number 3. Patch Connectivity 4. Linkage Area Characteristics 5. Landscape Matrix and Edge Effect 6. Anthropogenic Disturbances
General Suitability Descriptions	**Suitable:** Landscapes have connected mosaics of sagebrush shrublands that allow for bird dispersal and migration movements within the population or subpopulation area. Anthropogenic disturbances that can disrupt dispersal or cause mortality are generally not widespread or are absent. **Marginal:** Landscapes have patchy, fragmented sagebrush shrublands that are not well connected for dispersal and migration in portions of the population or subpopulation area. Anthropogenic disturbances that disrupt dispersal or cause mortality are present throughout all or portions of the landscape. Some lek groups or subpopulations are isolated or nearly isolated. **Unsuitable:** Landscapes were former shrubland habitat now converted to predominantly grassland or woodland cover or other unsuitable land cover or use. Remaining sagebrush patches are predominantly unoccupied or have few remaining birds. Portions of the population or subpopulation area may become occupied in the foreseeable future through succession or restoration.

Fine-Scale (Third-Order) Descriptions – Seasonal habitats within home ranges	
Habitat Indicators	1. Seasonal Habitat Availability 2. Seasonal Use Area Connectivity 3. Anthropogenic Disturbances
General Suitability Descriptions	**Suitable:** Home ranges have connected seasonal use areas. Anthropogenic features that can disrupt seasonal movements or cause mortality are generally absent or at least not widespread. **Marginal:** Home ranges have poorly connected or disjunct seasonal use areas. Anthropogenic features that can disrupt seasonal movements or cause mortality may occur within the home range. **Unsuitable:** Home ranges have seasonal use areas with predominantly grasslands, woodlands, or incompatible land uses (anthropogenic features) not conducive to sage-grouse seasonal movements or habitat use. Most leks have been abandoned or have few remaining birds.

Site-Scale (Fourth-Order) Descriptions – Use areas within seasonal habitats	
Habitat Indicators	1. Sagebrush Cover (all seasons) 2. Sagebrush Height (all seasons) 3. Predominant Sagebrush Shape (breeding only) 4. Perennial Grass and Forb Heights (breeding) 5. Perennial Grass Cover (breeding and summer/late brood-rearing) 6. Perennial Forb Cover (breeding and summer/late brood-rearing) 7. Preferred Forb Availability (breeding and summer/late brood-rearing) 8. Riparian Stability (summer/late brood-rearing) 9. Availability of Sagebrush Cover (leks and summer/late brood rearing – riparian/wet meadow) 10. Proximity of Detrimental Land Uses (leks) 11. Proximity of Trees or Other Tall Structures (leks)
General Suitability Descriptions	**Suitable:** Seasonal habitat has a preponderance of sagebrush cover types with sufficient shrub and herbaceous cover to protect sage-grouse from predators and weather and successfully raise young. Food resources are present or in close proximity to cover. **Marginal:** Seasonal habitat has a preponderance of sagebrush cover types with sparse shrub and/or herbaceous cover that does not provide the shelter needs for protection from predators and weather. Food resources are present but are either not at levels expected for ecological site potential or not in close proximity. **Unsuitable:** Seasonal habitat has a preponderance of land cover types that do not provide sufficient cover or food resources to meet the life requisite needs though there is potential to meet them in the future.

Broad Scale (First Order)

The broad-scale (first-order) habitat selection is the rangewide potential presettlement habitat of both species of sage-grouse (Schroeder et al. 2004) (figure 1). Connelly et al. (2004) provided figures that demonstrate the extent of the first order. Habitat suitability was demonstrated by evaluating sage-grouse numbers at leks distributed across the landscape (figure 2). This figure and its underlying dataset provide decisionmakers and conservation planners with a baseline from which they may begin the broad process of "visioning" the configuration of the landscape.

Connelly et al. (2004) discussed first-order sage-grouse habitat suitability in terms of characteristics such as availability of large expanses of sagebrush or grass/sagebrush habitat, presence of migration corridors, and juxtaposition of other habitats and land uses within these large expanses.

Mid Scale (Second Order)

Second-order habitat descriptions are linked to bird dispersal capabilities in population and subpopulation areas (figure 6). These population areas have been geographically described in a general manner for the Greater Sage-Grouse (Connelly et al. 2004; figure 7) and Gunnison Sage-Grouse (Gunnison Sage-Grouse Rangewide Steering Committee 2005; figure 1). A detailed description of the distribution of Greater Sage-Grouse populations and subpopulations is provided by Connelly et al. (2004). Second-order descriptions are generally appropriate for subpopulations. However, some isolated populations may warrant second- or third-order habitat descriptions.

The mix of sagebrush or grassland/sagebrush patches on the landscape at the second order also provides the life requisite of space for sage-grouse dispersal needs. The configuration of sagebrush or grassland/sagebrush habitat patches and the land cover or land use between the habitat patches within a subpopulation defines suitability. Landscape suitability at the mid scale for populations and subpopulations can generally be described by the following scenarios:

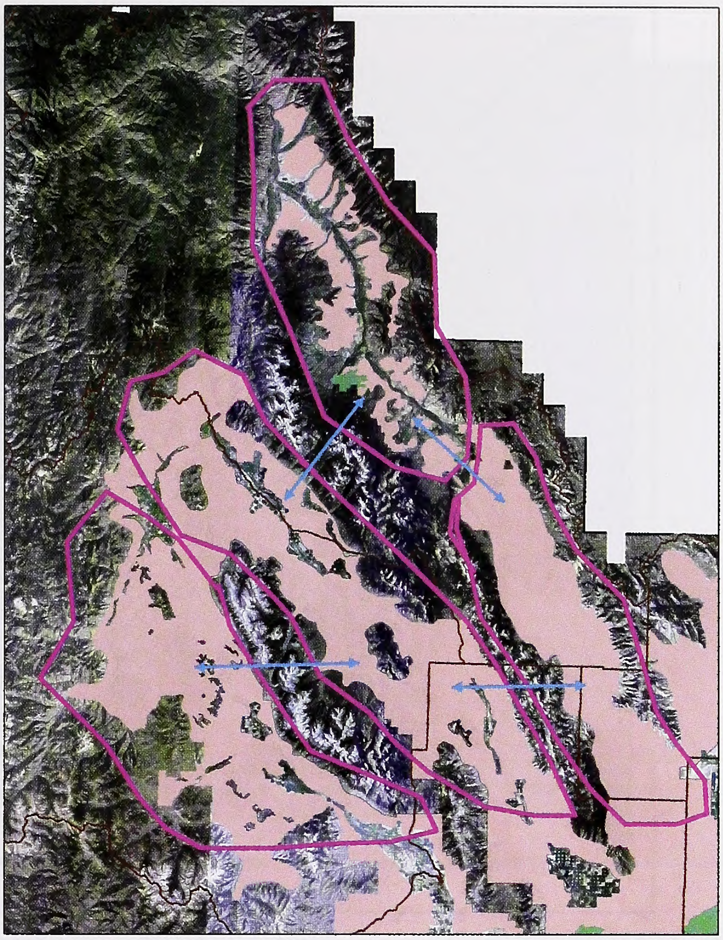


Figure 6. Mid-scale (second-order) habitat selection. The map demonstrates a series of interconnected subpopulations in mountain valleys.

- Suitable habitats within landscapes have connected mosaics of sagebrush shrublands that allow for bird dispersal and migration movements within the population and subpopulation area. Anthropogenic disturbances that can disrupt dispersal or cause mortality are generally not widespread or are absent.

- Marginal habitats within landscapes have patchy, fragmented, sagebrush shrublands or grasslands/sagebrush areas that are not well connected for dispersal and migration in portions of the population or subpopulation area. Marginal habitats could also include shrubland areas experiencing encroachment by junipers or other tree species. Anthropogenic

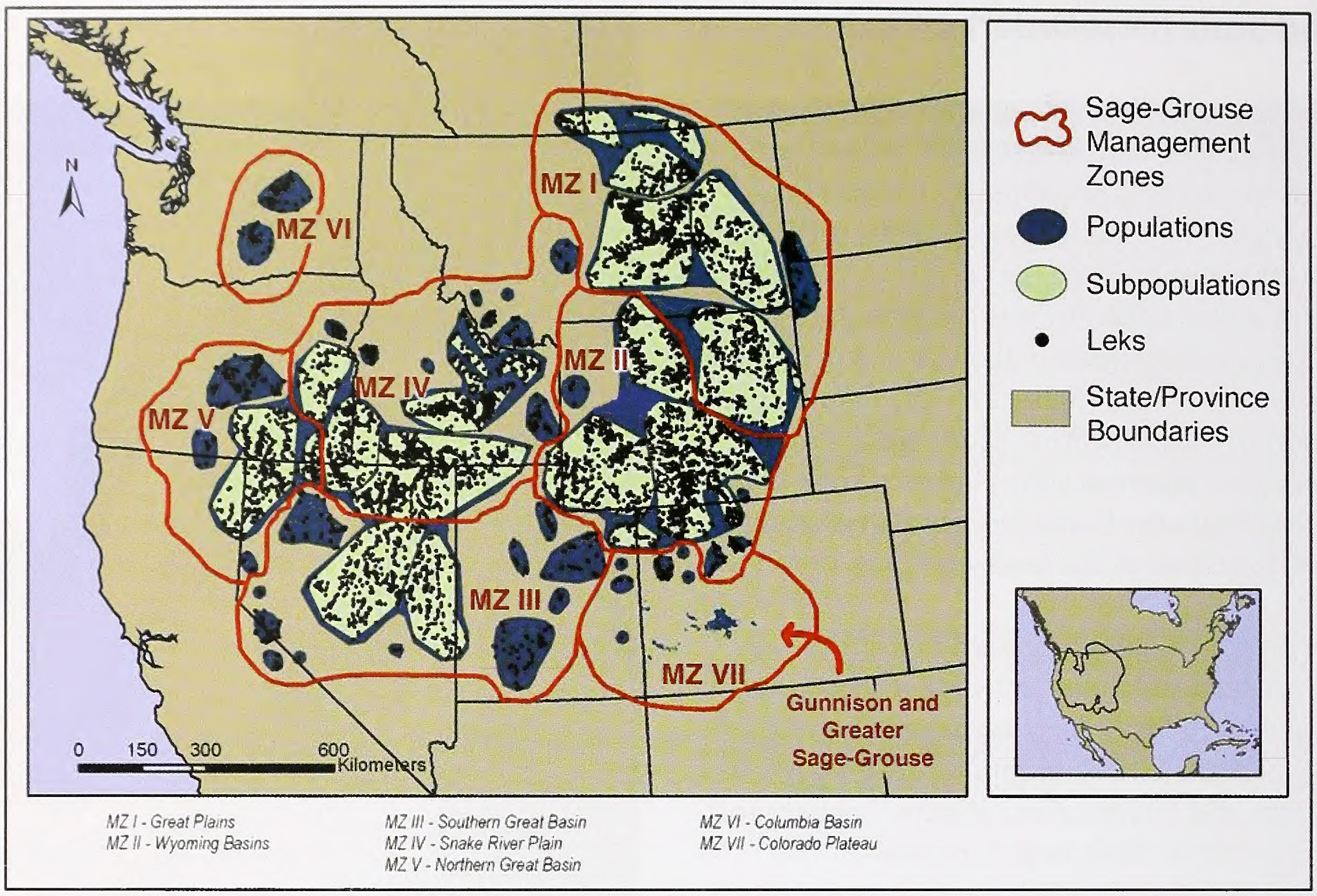

MZ I
MZ II
MZ III
MZ IV
MZ V
MZ VI
MZ VII
N
0 150 300 600 Kilometers
Gunnison and Greater Sage-Grouse
Sage-Grouse Management Zones
Populations
Subpopulations
Leks
State/Province Boundaries
MZ I - Great Plains
MZ II - Wyoming Basins
MZ III - Southern Great Basin
MZ IV - Snake River Plain
MZ V - Northern Great Basin
MZ VI - Columbia Basin
MZ VII - Colorado Plateau

Figure 7. Sage-grouse management zones and populations (Stiver et al. 2006).

disturbances that disrupt dispersal or cause mortality may be common throughout all or portions of the landscape. Some lek groups or subpopulations are isolated or nearly isolated.

- Unsuitable habitats often include large areas of former shrublands that have been largely converted to annual grasslands or shrublands or other land uses. Remaining habitat patches are predominantly or nearly unoccupied by sage-grouse. The area may or may not have some potential to become occupied in the foreseeable future through succession or restoration.

At the second order, sage-grouse occupancy and dispersal are dependent on the extent and pattern of sagebrush shrublands within a landscape matrix of nonhabitat and unsuitable habitat. Other habitats such as grasslands, wet meadows, and riparian areas provide important habitat for sage-grouse but only when they are in close proximity to sagebrush habitat (Connelly et al. 2004). The importance of these habitats is more appropriately addressed with seasonal habitat needs at the site scale.

Six second-order habitat indicators influence habitat use, dispersal, and movement across population and subpopulation areas (table 2):

1. Availability of sagebrush habitat.
2. Size and number of habitat patches.
3. Connectivity of habitat patches.
4. Characteristics of linkage areas between patches.
5. Landscape matrix and edge effects.
6. Anthropogenic disturbances.

Habitat suitability thresholds are poorly understood at the second order of habitat selection (Connelly et al. 2004). The relationships among indicators likely confound thresholds. Consistently describing subpopulation areas using these indicators across the range of the species may provide insights important in conservation planning. Comparing changes in these second-order indicators over time (e.g., between existing

Table 2. Mid-scale (second-order) habitat indicators and suitability characteristics for sage-grouse habitats.

Habitat Indicators	Metric Description	Habitat Suitability Characteristics
1. Habitat Availability	The amount of sagebrush habitat in the area.	The more sagebrush habitat relative to potential habitat, the greater the area's suitability.
2. Patch Size and Number	The average size of habitat patches and the number of patches within the area.	Generally, the larger and more contiguous the habitat patches relative to the area, the greater the suitability of that area.
3. Patch Connectivity	The average distance from one habitat patch to the nearest similar patch within the area.	As the average distance between sage-grouse habitat patches in the area decreases, suitability increases.
4. Linkage Area Characteristics	Percent shrub cover in relation to tree or grass/forb cover of areas between habitat patches through which sage-grouse move.	As linkage areas between habitat patches increase in shrub cover rather than tree or grass/forb cover, habitat suitability increases. Presence of anthropogenic features between patches also decreases linkage area suitability.
5. Landscape Matrix and Edge Effect	The amount of edge in contact with plant communities or land uses with positive or negative influences on the habitat patch.	As the amount of sagebrush edge in contact with plant communities or land uses that positively influence shrubland patch habitat increases, the landscape matrix and edge suitability increase.
6. Anthropogenic Disturbances	The fragmentation of contiguous sagebrush patches in the area through land use changes and infrastructure development. Measured as the number, length, or area (or area of influence) of embedded anthropogenic features per unit patch area.	As the number and intensity of anthropogenic features within the habitat patches in the area decrease, suitability increases.

conditions and those of an earlier reference period) provides information on habitat trends.

Knick et al. (2013) have identified ecological minimums required by sage-grouse in the western portion of their range. Both land cover of sagebrush and anthropogenic features including human activity were the primary variables that defined those minimums. Taylor et al. (2013) reported on anthropogenic stressors from oil and gas development and West Nile virus and their effects on sage-grouse at this scale. Patch size, connectivity, habitat linkage, and landscape matrix thresholds for sage-grouse need further study.

Quantifying existing habitat conditions using the six indicators and population monitoring will help reveal habitat and population relationships, and comparing existing conditions over time or a reference period could be helpful for describing habitat trends associated with second-order indicators. However, the spatial analysis skills or tools and availability of adequate vegetation datasets needed for these types of analyses are limited in many cases, so agencies, academia, and other conservation partners are encouraged to work together to build capacity in this regard.

Habitat availability, patch size, and patch connectivity are major components of suitability in the second order. The amount of occupied habitat within the landscape matrix of nonhabitat and unsuitable habitat is important to describe (table 2, indicator 1). In some areas, the ratio of suitable to marginal to unsuitable habitat would be an important conservation statistic for measuring habitat restoration progress. The more sagebrush habitat relative to potential habitat, the greater the area's suitability. Whether the available habitat is contained in one large habitat patch or several patches (indicator 2) could influence sage-grouse use and dispersal between subpopulations (figure 8). Dispersal could be uninterrupted in large habitat patches, whereas movement between smaller patches may be disrupted, depending on the configuration of the patches and landscape matrix in which they are embedded. Generally, the larger and more contiguous the sagebrush patches of a population or subpopulation are, the greater the suitability of that area. The closer the

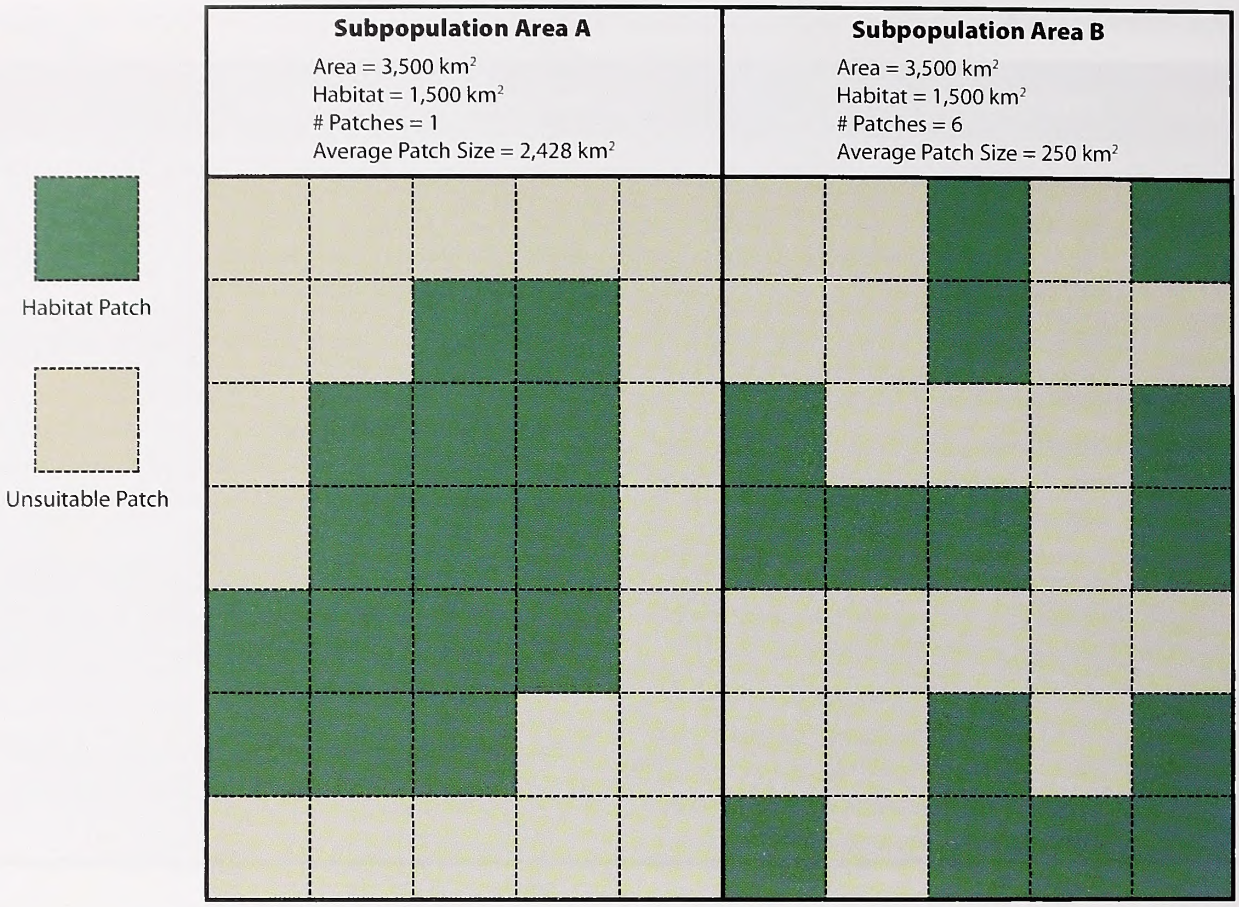


Figure 8. Habitat patches in two similar subpopulation areas. Areas A and B have similar total area and habitat quality, but area A has one large habitat patch while area B has several smaller ones. In area A, sage-grouse can freely disperse. The distance between patches in area B is great enough to limit sage-grouse movement between the patches, potentially affecting habitat suitability.

suitable habitat patches are to each other, the more likely sage-grouse can move freely between them (indicator 3).

Habitat linkage and patch edges forming a matrix on the landscape can greatly influence habitat use and dispersal within and between occupied areas. The landscape context in which patches are located has a bearing not only on habitat suitability for dispersal between patches but also on the likelihood that the habitat patches will persist into the future (Morrison et al. 1998). Resource managers, planners, and decisionmakers should evaluate existing or potential pathways from habitat patch to habitat patch. Barriers that compromise sage-grouse movements between habitat patches are not completely understood and are variable (Connelly et al. 1988; Leonard et al. 2000; Beck et al. 2006; Knick and Hanser 2011). Linkage area suitability is believed to improve as the percent of shrub cover (not necessarily sagebrush) increases relative to tree or grass cover in the areas between the habitat patches (indicator 4). The cover type or land use immediately adjacent to a habitat patch can positively or negatively affect the quality of that patch's suitability as sage-grouse habitat. Adjacent land cover types also differ in (1) mortality risks posed to birds occupying the habitat patch, (2) influence on existing patch quality, and (3) influence on patch and habitat persistence. As the amount of sagebrush edge in contact with plant communities or land uses that positively influence shrubland patch habitat increases, the landscape matrix and edge suitability increase (figure 9) (indicator 5). This is termed "positive edge" (Ries et al. 2004). Edge effects associated with roads and other linear anthropogenic features within habitat patches are discussed later as a component of fragmentation within the habitat patch.

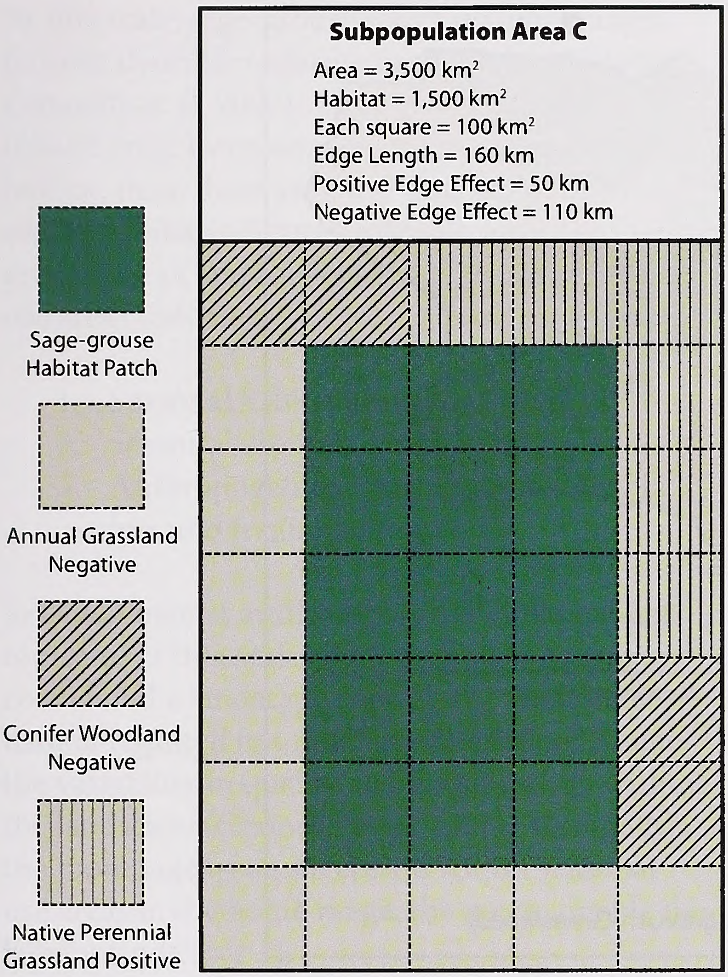

Subpopulation Area C
Area = 3,500 km²
Habitat = 1,500 km²
Each square = 100 km²
Edge Length = 160 km
Positive Edge Effect = 50 km
Negative Edge Effect = 110 km
Sage-grouse Habitat Patch
Annual Grassland Negative
Conifer Woodland Negative
Native Perennial Grassland Positive

Figure 9. A habitat patch depicting a function of contrast and (dis)similarity. These communities greatly affect future risks to sage-grouse populations and habitat suitability.

Anthropogenic disturbances influence sage-grouse habitat, numbers, and distribution at each order of habitat selection (indicator 6). Anthropogenic features can affect sage-grouse demographics or habitat use in two significant ways:

- Anthropogenic features may directly and indirectly cause mortality, which can then affect the long-term sustainability of the population or subpopulation. The mortality significance of the features depends on their scope and intensity. However, an increase in anthropogenic features in otherwise suitable habitat increases the probability that the habitat will become a sink habitat rather than a source habitat (Aldridge 2005). Effects of the human footprint may not be readily apparent in the immediate population response, but over time, and if the scope and intensity of these features increase, there will likely be a negative impact on population trend (Connelly et al 2004; Aldridge 2005; Holloran 2005; Wisdom et al. 2005).
- Sage-grouse eventually avoid areas with a high density of anthropogenic features even if site-scale conditions are suitable (Connelly et al. 2004). While there is still much to learn about the dispersal and home range selection process, there is mounting evidence that sage-grouse are sensitive to human disturbances and will avoid areas they once used if those areas have been altered by anthropogenic features that exceed some threshold (Connelly et al. 2004; Aldridge 2005; Holloran 2005; Johnson et al. 2011; Knick et al. 2011; Knick et al. 2013). The anthropogenic feature thresholds that affect these selection processes likely vary depending on type of use, seasons of use, intensity of use, cumulative extent of features, topography, and other factors. However, if these changes occur quickly on the landscape, sage-grouse may not recognize the risks associated with these features and may not show an immediate avoidance response (Aldridge 2005; Aldridge and Boyce 2007).

Fine Scale (Third Order)

Sage-grouse select seasonal habitats (third-order habitats) within their home ranges, including breeding, summer, and winter habitats (figure 10) (Johnson 1980; Connelly et al. 2004). For many wildlife species with large home ranges, including sage-grouse, seasonal life requisite needs differ, and movement is required to meet seasonal shelter and food needs. Sage-grouse are generally traditional in their seasonal movement patterns (Schroeder et al. 1999; Connelly et al. 2004; Holloran 2005). Some sage-grouse may move long distances (>30 km) from breeding to summer and from summer and to winter habitats. Fedy et al. (2012) reported high variability of movement distances within and among seasonal habitats. Sage-grouse diets shift from insects and forbs during breeding and summer seasons to sagebrush during winter (Berry and Eng 1985; Schroeder et al. 1999; Connelly et al. 2004). The life requisite

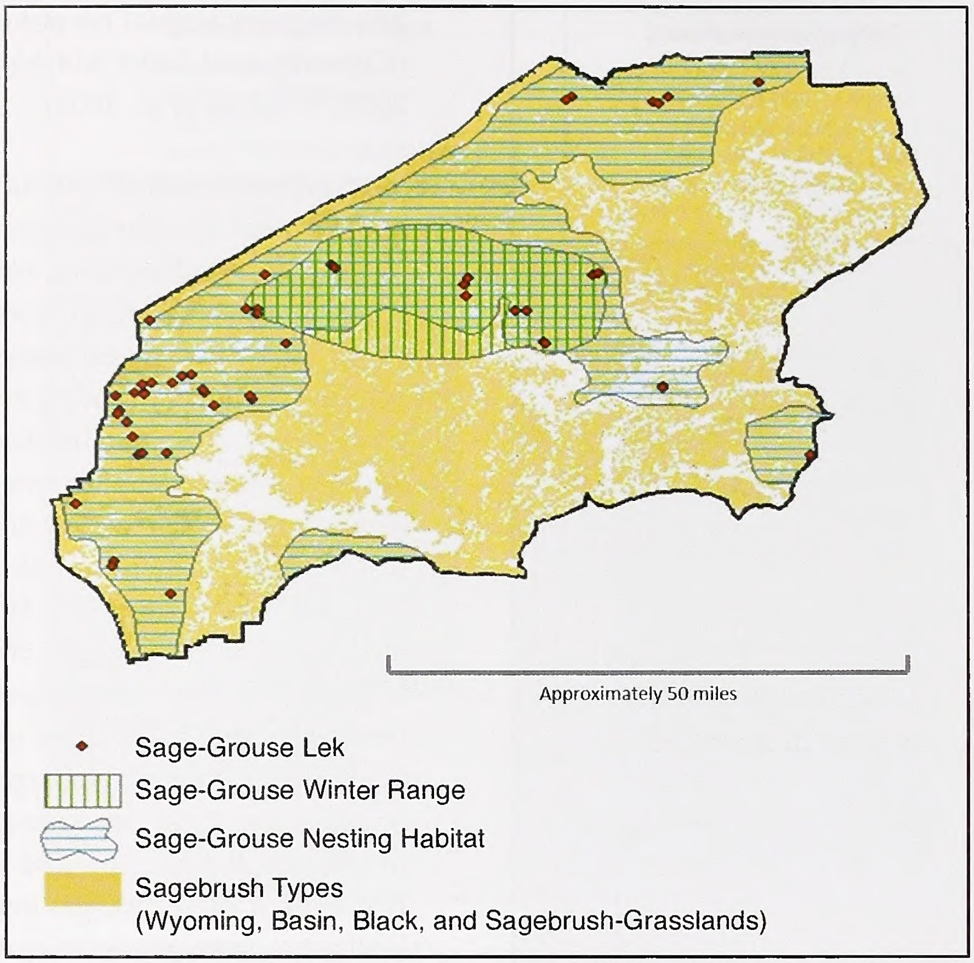


Figure 10. Fine-scale (third-order) habitat selection.

"space" is still a predominant need for sage-grouse to access their seasonal food and shelter needs at the fine scale.

Third-order habitat descriptions should address factors that affect sage-grouse use of, and movements between, seasonal use areas. Seasonal home ranges for sage-grouse associated with a lek or lek group within a population or subpopulation area should be the habitat focus. In some cases, small isolated populations or subpopulations may be the focus of fine-scale descriptions. Habitat suitability at the fine scale can generally be described as follows:

- Suitable habitats within home range areas have contiguous mosaics of sagebrush shrublands or grassland/sagebrush connecting seasonal use areas. Anthropogenic features within home ranges that can disrupt seasonal movements or cause mortality are generally absent or at least not widespread.
- Marginal habitats within home range areas have patchy, disjunct sagebrush shrublands or grassland/sagebrush between seasonal use areas or may exhibit some degree of tree/conifer encroachment. Anthropogenic features that can disrupt seasonal movements or cause mortality may occur within the home range.
- Unsuitable habitats within a home range area are potential shrublands currently dominated by perennial or annual grasses, invasive woodlands (e.g., western juniper), or incompatible land uses (some anthropogenic features) not conducive to sage-grouse seasonal movements or habitat use. Most leks have been abandoned or have few remaining birds. Other unsuitable habitat examples include conifer encroachment (>4 percent canopy cover); severe topographical features such as deep canyons; and lands converted to farmland, urban areas, reservoirs, etc.

At this scale, sage-grouse select seasonal ranges to meet their life requisite needs (Johnson 1980; Connelly et al. 2003). Sage-grouse generally inhabit large interconnected areas of sagebrush habitat, thus, there are three fine-scale (third-order) habitat indicators that influence sage-grouse use of and movements between seasonal use areas (table 3):

1. Seasonal habitat availability.
2. Seasonal use area connectivity.
3. Anthropogenic disturbances and habitat loss and fragmentation.

Seasonal habitat availability is the initial habitat indicator at this scale. Although sage-grouse are considered a landscape species, the amount of habitat required has not been determined due to the variability in quality and juxtaposition within the landscape (Connelly et al. 2011). Generally, the more sagebrush shrubland within seasonal use areas in the home range, the more suitable the habitat (indicator 1).

The availability and connectivity of sagebrush within seasonal use areas of sage-grouse home ranges can affect suitability. To address this, seasonal use areas need to be identified and mapped. Descriptions of the availability of other forb-rich habitats in summer and fall areas is also important at this scale, particularly if these habitats are in close proximity to sagebrush-dominated communities.

Following nesting, hens often move chicks to summer ranges for food. Connectivity between breeding and summer brood-rearing habitats is particularly important due to the restricted flight capability of chicks at this time. In general, the more contiguous the sagebrush cover between seasonal use areas, the more suitable the habitat (indicator 2). In some areas, other shrub communities may provide important connecting habitat between seasonal use areas.

There is increasing evidence that anthropogenic disturbances within a home range can cause local extirpations even if other habitat conditions appear suitable (Aldridge 2005; Holloran 2005; Aldridge et al. 2008). Anthropogenic features can affect sage-grouse in two significant ways at the fine scale. Anthropogenic features directly and indirectly increase mortality or decrease recruitment, and sage-grouse may eventually avoid seasonal use areas with a high density of anthropogenic features even if site-scale conditions are suitable (indicator 3). Anthropogenic features can also facilitate the intrusion of avian and mammalian species that directly depredate sage-grouse, or they may promote the spread of exotic plant species such as cheatgrass or noxious weeds that alter the

Table 3. Fine-scale (third-order) habitat indicators and suitability characteristics for sage-grouse habitat seasonal use areas within home ranges (in terms of potential barriers to movement, reproduction, and survival).

Habitat Indicators	Metric Description	Habitat Suitability Characteristics
1. Seasonal Habitat Availability	The amount of sagebrush shrubland in seasonal use areas. The amount of other forb-rich habitats in summer/fall seasonal use areas.	The more sagebrush shrubland within seasonal use areas in the home range, the greater the area's suitability. Other forb-rich habitats in summer/fall seasonal use areas are available.
2. Seasonal Use Area Connectivity	The extent of sagebrush connectivity between seasonal use areas.	As areas between seasonal use areas increase in sagebrush cover, habitat suitability increases.
3. Anthropogenic Disturbances	The disruption of movement between or use of seasonal use areas within a home range due to land use changes and infrastructure development. Measured as the number, length, or area of anthropogenic features within a home range area.	As the number and significance of anthropogenic features within a home range decrease, suitability increases.

suitability of habitats (Lyon 2000; Lyon and Anderson 2003; Holloran 2005; Aldridge 2005).

Site Scale (Fourth Order)

Habitat suitability at the site scale (fourth order) describes the more detailed vegetation indicators of seasonal habitat such as canopy cover and height of sagebrush (nesting and wintering); the associated understory vegetation (breeding, nesting, and early brood-rearing); and vegetation associated with riparian areas, wet meadows, and other mesic habitats adjacent to sagebrush (summer/late brood-rearing) (figure 11). Based on extensive research in many western states, Connelly et al. (2000) developed and Hagen et al. (2007) reviewed habitat criteria or indicators required by sage-grouse for specific seasonal needs (breeding, summer, and wintering). While general criteria were recommended, Connelly et al. (2000) recognized that ecological site potential should be considered at the site scale. Hagen et al. 2007 provided a meta-analysis of existing research on nesting and brood-rearing habitats. Generalized seasonal habitats are characterized as (1) breeding habitat—habitat for prelaying hens, leks, nesting, and early brood-rearing; (2) summer/late brood-rearing habitat; (3) fall habitat; and (4) winter habitat. Connelly et al. (2000) provided extensive treatment of each of these seasonal ranges. Tables 4 through 7 summarize seasonal habitat indicators at the fourth order.

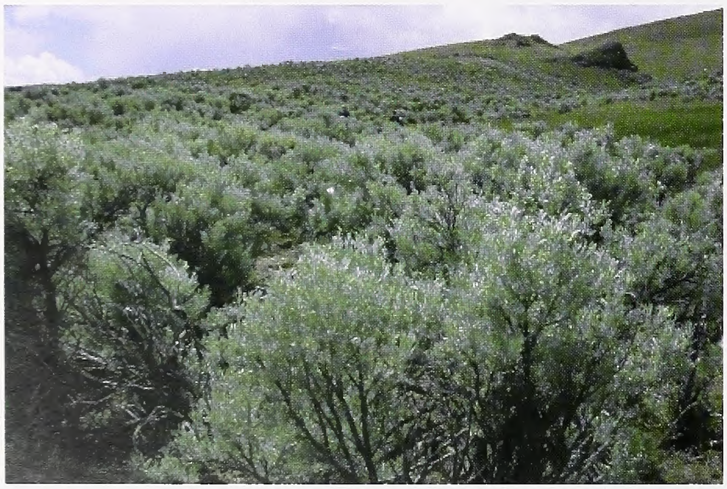


Figure 11. Site-scale (fourth-order) habitat selection.

The various site-scale seasonal habitat criteria or indicators referenced above have been further interpreted in the HAF to provide a range of habitat categories that facilitate sage-grouse habitat evaluations and conservation planning. Suitable habitats provide the appropriate protective cover (sagebrush and herbaceous plants), food (forbs, insects, and sagebrush), and security (few or no trees or tall structures for predators) needs for sage-grouse to survive and reproduce (Connelly et al. 2000; Sather-Blair et al. 2000). Marginal habitats include habitat components to support sage-grouse, but habitat conditions are lower in quality compared to suitable habitats and does not provide shelter from predators and weather. Survival and reproduction rates are assumed lower in marginal habitats compared to suitable habitats (Cooperrider et al. 1986; Morrison et al. 1998). Unsuitable habitats are currently missing one or more of the basic life requisites of food or shelter, though they may have the potential to provide these life requisites in the future. In all cases, professional judgment and experience are needed to describe suitability in the appropriate context.

Table 4. Site-scale (fourth-order) breeding habitat indicators and suitability characteristics for lek sites (Connelly et al. 2000).

Habitat Indicators	Metric Description	Habitat Suitability Characteristics
1. Availability of Sagebrush Cover	Lek has adjacent sagebrush cover in close proximity.	Adjacent sagebrush cover within 100 meters.
2. Proximity of Detrimental Land Uses	The distance to land uses that have detrimental effects on lek use. Sonic and physical disturbances such as highways, railroads, and industrial parks are examples.	Detrimental land uses are not within line of sight of lek and absent to uncommon within 3 km of lek.
3. Proximity of Trees or Other Tall Structures	The presence of trees or other tall structures within line of sight of leks.	Trees or other tall structures are not within line of sight of lek and absent or uncommon within 3 km of the lek.

Table 5. Site-scale (fourth-order) breeding habitat indicators and suitability characteristics for nesting and early brood-rearing sites.

Habitat Indicators	Metric Description	Habitat Suitability Characteristics	
		Arid Sites[1]	Mesic Sites[1]
1. Sagebrush Cover	Average percent cover for land cover type.	15–25%	15–25%
2. Sagebrush Height	Average sagebrush height for land cover type.	30–80 cm (12–30 inches)	40–80 cm (15–30 inches)
3. Predominant Sagebrush Shape[2]	Number of sagebrush plants by shape and most common sagebrush shape for land cover type.	Spreading	Spreading
4. Perennial Grass and Forb Heights	Average maximum heights in land cover type.	≥18 cm (≥7 inches)	≥18 cm (≥7 inches)
5. Perennial Grass Cover	Average percent cover for land cover type.	≥10%	≥15%
6. Perennial Forb Cover	Average percent cover for land cover type.	≥5%	≥10%
7. Preferred Forb Availability	Number of preferred forbs in land cover type.	Good abundance and availability relative to ecological site potential	

[1] Mesic and arid sites should be defined on a local basis; annual precipitation, herbaceous understory, and soils should be considered (Connelly et al. 2000).

[2] Sagebrush plants that are more tree- or columnar-shaped, with no or few lower branches, provide less protective cover near the ground than sagebrush plants with a spreading shape. Basin big sagebrush (*Artemisia tridentata* spp. *tridentata*) plants often have this columnar shape, as do other sagebrush species or subspecies that have been heavily browsed or rubbed. Sagebrush communities in which the columnar shrub shape is predominant are assumed likely to require more herbaceous cover to compensate to provide adequate protection for nesting sage-grouse and young broods. Conversely, in suitable habitat, the spreading shape should be predominant; however, there may be a small proportion of columnar plants present.

Table 6. Site-scale (fourth-order) habitat indicators and suitability characteristics for summer/late brood-rearing habitat (Connelly et al. 2000).

Habitat Indicators	Metric Description	Habitat Suitability Characteristics	
		Upland Sagebrush Communities[1]	Riparian and Wet Meadow Communities
1. Sagebrush Cover	Average percent cover for land cover type.	10–25%	
2. Sagebrush Height	Average sagebrush height for land cover type.	40–80 cm (15–30 inches)	
3. Availability of Sagebrush Cover	Food site has sagebrush cover in close proximity.		Sagebrush cover is within 100 m of riparian or wet meadow foraging area.
4. Perennial Grass and Forb Cover	Average percent cover for land cover type.	≥15%	
5. Riparian Stability	Functioning condition.		The majority of riparian areas are in proper functioning condition.
6. Preferred Forb Availability	Number and density of preferred forbs in land cover type.	Good abundance, diversity, and availability relative to ecological site potential.	

[1] In areas where agricultural fields provide the food resources, the habitat indicators for protective cover apply.

Table 7. Site-scale (fourth-order) habitat indicators and suitability characteristics for winter habitat (Connelly et al. 2000).

Habitat Indicators	Metric Description	Habitat Suitability Characteristics
1. Sagebrush Cover	Average percent cover exposed above snow in wintering area.	≥10–30% exposed above snow.
2. Sagebrush Height	Average height above snow in wintering area.	≥25–35 cm (10–14 inches) exposed above snow.

To ensure consistency in reporting and communicating field data, seasonal habitat suitability matrices should NOT be revised unless warranted by scientific evidence. Guidelines for managing sage-grouse habitats have been published by Connelly et al. (2000) and evaluated by Hagen et al. (2007). These guidelines describe characteristics of productive sage-grouse habitats based on a large number (n=24) of studies conducted throughout the species' range. These guidelines are often included in various management plans and planning documents. However, this information should not be viewed as providing standards by which to judge the overall quality of sagebrush habitats. Instead, these sage-grouse habitat characteristics should be used as tools for assessing habitats and guiding management actions.

Connelly et al. (2000) stated that there may be a need to develop adjustments to height and cover requirements and emphasized that any such adjustments should be reasonable and ecologically defensible. To foster consistency, making adjustments to site suitability indicator values at the local scale should be avoided unless there is strong, scientific justification for doing so. Regional adjustments must be supported by regional plant productivity and habitat data and in floristic provinces and sage-grouse management zones as reported by Connelly et al. (2004) and Stiver et al. (2006). If adjustments are made to the site-scale indicators, they must be made using nesting and brood-rearing data collected from sage-grouse studies found in the relevant area and peer reviewed by the appropriate wildlife management agency(ies) and researchers.

Similarly, regional research may suggest the need to adjust habitat management guidelines or quantitative indicator values in the HAF's site-scale suitability matrices. However, these matrices are designed to organize field data into a useful format for consistency and communication, so changes in criteria should only be made after considerable coordination and only if scientific evidence warrants their adjustment. There is a tendency to review each indicator and its suitability category independently, but site suitability is determined by the relationship among the several indicator values in each matrix. The suitability classes for these matrices are based on rangewide plant productivity and structural data and expert opinion relative to sage-grouse use. Finally, it is important to recognize that the term "suitable" is not synonymous with "optimum."

In some parts of the range, the indicators will need to be interpreted with a regional perspective. For example, the sagebrush cover may be naturally high in some portions of the sage-grouse range, but herbaceous cover capability, based on site potential, may be below the height identified in the guidelines; thus, adequate cover for sage-grouse may still be present. In other portions of the range, sagebrush cover may be below those found in the guidelines, but herbaceous cover may be high and providing adequate cover for nesting.

Invasive plants, especially invasive annual grasses, that occur in many sagebrush habitats can have deleterious effects on sage-grouse habitat and therefore should be documented. While sage-grouse habitat may be directly affected by invasive plants through competitive exclusion of native plants that provide cover and forage (Rowland et al. 2010; Mooney and Cleland 2001), the most significant impacts of invasive plants on sage-grouse habitat are indirect through alteration of fire regimes. Invasive annual grasses generally provide for continuous ground cover that facilitates greater frequency and intensity of fires creating annual grass dominated habitats compared to native perennial habitats that are dominated by sparse, discontinuous fuels (Balch et al. 2013; Antonio and Vitousek 1992). The resulting increased frequency and intensity of fires result in changes in life form classes from shrubs to grasses, and species composition becomes dominated by annuals, providing little value for food and cover for sage-grouse (Connelly et al. 2004; Davies et al. 2011; Miller et al. 2011).

While sage-grouse may occupy habitats where shorter statured Sandberg bluegrass (*Poa secunda*) is dominant in the understory, this is not sufficient reason to assume that the suitability indicator value for grass height should be reduced, especially if the ecological site potential is for larger bunchgrasses. Rather, this condition may indeed reflect reduced habitat suitability and likely indicates a rangeland health issue that should be addressed via appropriate restoration activities or management changes. These examples illustrate that individual indicator values do not define site suitability and that overall site suitability descriptions require an interpretation of the relationships between the indicators and other factors. Professional expertise and judgment are required.

Habitat Description Steps

Habitat description steps are identified for each scale. Descriptions for the first and second order are brief. Descriptions and evaluations of habitat at these scales have been completed or are in the process of being completed through ecosystemwide assessments. These assessments have been tasked by agencies including the BLM, U.S. Forest Service, and U.S. Geological Survey and nongovernmental organizations, including The Nature Conservancy. Policy-level officials, scientists, spatial analysts, and resource managers need to access these evaluation efforts to reach decision points for each scale.

Broad Scale (First Order) and Mid Scale (Second Order)

Considerable broad-scale and mid-scale information is available for Greater Sage-Grouse range (Schroeder et al. 2004) and populations (Connelly et al. 2004) as well as for Gunnison Sage-Grouse (Gunnison Sage-Grouse Rangewide Steering Committee 2005). Stiver et al. (2006) identified seven sage-grouse management zones that conform to seven clusters of habitat and populations described in Connelly et al. 2004 from Kuchler (1970), West (1983), and Miller and Eddleman (2001) (figure 7). The management zones provide a first- and second-order context for management purposes. There are also several regional assessments describing shrub steppe habitat (table 8). These assessments provide critical information necessary for finer scale habitat descriptions as they provide scale context to habitats and populations (Connelly et al. 2004; Wisdom et al. 2005; Aldridge et al. 2008). In addition, these assessments describe and evaluate disturbances to landscapes and resulting habitat patterns operating at the population and species range scales. Large landscape features and disturbances influence the distribution and abundance of sage-grouse on the landscape. The BLM has also conducted six rapid ecoregional assessments over the range of Greater and Gunnison Sage-Grouse that examine ecological values, conditions, and trends within ecoregions. Greater and Gunnison Sage-Grouse populations/subpopulations as described by the U.S. Fish and Wildlife Service (2013) and Gunnison Sage-Grouse Rangewide Steering Committee (2005) are shown in figure 3 (see chapter 1).

From a practical standpoint, the management of sagebrush/sage-grouse habitats at the first order of habitat selection requires policy at the management zone that contributes to policy for

Table 8. Rangewide and regional assessments containing information on sage-grouse or their habitat.

Species	Assessment Area	Citations
Greater Sage-Grouse	Rangewide (OR, WA, CA, NV, ID, UT, MT, WY, CO, NM, AB, SK)	Connelly et al. 2000; Miller and Eddleman 2001; Connelly et al. 2004; Aldridge et al. 2008; Knick and Connelly 2011
Greater Sage-Grouse	Upper Columbia River Basin (OR, WA)	Hann et al. 1997; Wisdom et al. 2000
Greater Sage-Grouse	Great Basin (ID, NV, UT, CA)	Wisdom et al. 2005
Greater Sage-Grouse	Wyoming Basin (WY, CO, MT, UT, ID)	Rowland et al. 2006a
Gunnison Sage-Grouse	Rangewide (CO, UT)	Gunnison Sage-Grouse Rangewide Steering Committee 2005

the range of sage-grouse. Each management zone, evaluated by the various regional assessments, provides policymakers with parameters to match policy to realistic outcomes.

Management and management direction for second-order scales require the use of existing broad-scale data and the application of GIS tools for analysis. These evaluations should document existing conditions (see form M-1 in appendix B), assess potential for habitat manipulation, and consider landscape constraints. Landscape scientists and spatial analysts may provide decisionmakers with a vision of the future landscape matrix.

Fine Scale (Third Order)

Ecological processes of interest at the third order of habitat selection are those that may affect sage-grouse movements between seasonal habitats within a home range (table 9). Habitat needs and the indicators that describe life requisite needs vary by season. Third-order habitat assessments take into account seasonal use areas or home ranges of sage-grouse associated with a lek or group of leks. Seasonal habitat availability, connectivity, and anthropogenic disturbances should be described at this scale. Third-order habitat mapping uses the information gathered at the mid-scale and refines it to show seasonal habitat patterns for a home range of interest.

At this scale, identifying seasonal habitat use areas to the extent possible is important. Habitat and wildlife resource specialists, along with people with local knowledge, should jointly evaluate sage-grouse seasonal distribution evidence to determine the presence or absence of sage-grouse. In the absence of telemetry data or other seasonal use data or models, wildlife biologists who understand sage-grouse habitat selection and needs can effectively predict how sage-grouse make seasonal use of their habitats. In many cases, mapping seasonal habitats will occur incrementally over time and in higher priority landscapes first due to limited staffing and funding resources.

Table 9. Summary of fine-scale (third-order) ecological processes (Johnson 1980), mapping features, and management levels for sage-grouse habitat descriptions.

Ecological Processes	
Ecological Time Period	5–20 years in the future
Climatic Processes	Local weather patterns: localized drought, rain shadow areas
Landscape Processes	Local-scale processes that have long- and short-term consequences on home range use, seasonally and year-round: conversion of sagebrush habitat between seasonal ranges to nonhabitat or unsuitable habitat, anthropogenic features that act as filters or barriers to seasonal movements
Population Processes - Habitat Dynamics	Connectivity of sagebrush habitat and other adjacent habitats provide for effective use of seasonal habitats within a home range, seasonal migration corridors are maintained, collective fitness of birds within the home range is sufficient for long-term persistence
Mapping Features	
Extent	Seasonal habitats within a home range
Grain	Fine grain (30-meter pixel size)
Vegetation Cover Types	Associations or groups thereof
Geographic Extent Equivalents	Subbasins or group of watersheds
Cartographic Scale Range	e.g., 1:24,000–1:100,000
Management Levels	
Administrative Hierarchical Level	Local county governments, BLM field offices or subunits, Forest Service national forests/ranger districts
Planning and Assessment Documents	BLM activity plans (e.g., habitat or allotment management plans), forest plans, watershed assessments, and land use plans

The steps to describe sage-grouse habitat at the fine scale (third order) are as follows:

Step 1. Determine the extent and grain size appropriate for a habitat description of the home range area. Develop a vegetation map using appropriate third-order land cover types.

Identify sage-grouse populations or subpopulations as described by the U.S. Fish and Wildlife Service (2013) and Gunnison Sage-Grouse Rangewide Steering Committee (2005) and shown in figure 3 (see chapter 1). Delineate the home range area of interest and document the grain size for the analyses needed. Generally, a 30-meter pixel size is desired for third-order descriptions. Remote data should be collected at as fine a scale as available and affordable and should be aggregated at the 30-meter pixel resolution. Third-order habitat descriptions require more detailed vegetation information for an area. Identify natural vegetation cover types using information from the National Vegetation Classification System (see http://usnvc.org/ or http://www.natureserve.org/conservation-tools/projects/us-national-vegetation-classification). Land cover datasets are constantly being refined or improved upon, so use the latest, most appropriate product or version. Distinguishing between sagebrush alliances (Reid et al. 2002) to help identify seasonal habitat availability and connectivity of different sagebrush communities is important (table 10). Distinguishing between certain nonhabitat types, such as salt desert shrub, forest/woodland, and agricultural lands, is also important. Pasture lands or conservation reserve program lands adjacent to sagebrush habitat may provide summer food resources with little risk from pesticides or mowing. Conversely, sage-grouse use of agricultural lands, such as row crops adjacent to sagebrush, may be hazardous to sage-grouse because of risk of mortality from mechanical equipment (e.g., mowing) or chemicals.

Step 2. Map occupied seasonal habitats and identify potential habitat by seasonal use period.

Occupied and potential seasonal habitats should be mapped in cooperation with the state wildlife agency. Historic and current data and knowledge

Table 10. Example of basic sagebrush land cover types needed for mid-scale (second-order) habitat descriptions. Fine-scale (third-order) cover types are generally shrubland alliances as described by Reid et al. (2002). NP = native perennial grass, EP = exotic perennial grass, EA = exotic annual grass.

Mid-Scale Cover Types (overstory/understory)	Fine-Scale Cover Types (overstory/understory)	
Sagebrush/Native Perennial Grass	Wyoming and basin big sagebrush/NP Black sagebrush/NP Low sagebrush/NP Low sagebrush – mountain big sagebrush/NP Low sagebrush – Wyoming big sagebrush/NP Mountain big sagebrush/NP	Rigid sagebrush/NP Silver sagebrush/NP Threetip sagebrush/NP Wyoming big sagebrush – squawapple/NP Gambel Oak – Basin big sagebrush shrubland/NP
Sagebrush/Exotic Perennial Grass	Wyoming and basin big sagebrush/EP Black sagebrush/EP Low sagebrush/EP Low sagebrush – mountain big sagebrush/EP Low sagebrush – Wyoming big sagebrush/EP	Mountain big sagebrush/EP Rigid sagebrush/EP Silver sagebrush/EP Threetip sagebrush/EP Wyoming big sagebrush – squawapple/EP
Sagebrush/Exotic Annual Grass	Wyoming and basin big sagebrush/EA Black sagebrush/EA Low sagebrush – mountain big sagebrush/EA Low sagebrush – Wyoming big sagebrush/EA Mountain big sagebrush/EA	Rigid sagebrush/EA Silver sagebrush/EA Threetip sagebrush/EA Wyoming big sagebrush – squawapple/EA

from local sage-grouse experts should be used to help identify seasonal use areas and to determine the migratory status of the population. In some areas, seasonal habitats will overlap (e.g., breeding and winter or late brood-rearing/summer). In other areas, seasonal habitat may be separated by many miles. Three main sage-grouse seasonal habitats (breeding, which is composed of lekking, prelaying, nesting, and early brood-rearing; summer/late brood-rearing; and winter) should be identified (table 11). If seasonal use patterns are unknown, mapping the vegetation and elevations will help identify them. State wildlife agencies, federal agencies, or university researchers may have telemetry data or other information that can be used as well. In addition, predictive modeling as described by Yost et al. (2008) can be used to help identify seasonal habitats.

Breeding Habitat: The breeding period typically occurs from March 1 through late June and includes the period when sage-grouse attend leks to breed, prepare nutritionally for nesting, nest, and raise young chicks (Connelly et al. 2000). Breeding habitat includes all sagebrush types that may be used during this timeframe. Sage-grouse require a mixture of sagebrush, grasses, and forbs for adequate breeding habitat. Sagebrush cover types within 18 km (11 miles) of a lek for migratory populations and 5 km (3.1 miles) for nonmigratory populations are considered breeding habitat and are mapped as such unless this distance includes sagebrush communities that sage-grouse would not use for nesting (e.g., deep canyon areas, sagebrush areas typically covered by deep snow, or sagebrush areas compromised by anthropogenic disturbances). Mapping sagebrush habitats at this scale, with the exclusion of canyon areas and other areas not used for nesting, can be readily accomplished using routine GIS techniques and available land cover and digital elevation data. The accuracy of some thematic vegetation data can be problematic, so users need to understand the limitations of the data. In addition, there may be some sagebrush cover types that do not provide suitable breeding habitat due to plant structure characteristics or because of edaphic conditions, steep slopes, aspect, or other factors that are important locally. Map known nesting and early brood-rearing areas if telemetry data or other observational data are available.

Summer/Late Brood-Rearing Habitat: Summer is generally described as that period between July 1 and September 30 (Connelly et al. 2000). During summer, sage-grouse are found in areas with succulent forbs adjacent to or intermixed with sagebrush. Hens generally move their chicks to more mesic conditions, such as higher elevation sagebrush communities, mountain shrub communities, wet meadow complexes, agricultural fields, perennial lakes, streams, ponds, or lakebeds adjacent to sagebrush, during the summer months. Riparian areas associated with steep drainages or canyons typically are not used by sage-grouse and should not be mapped as summer habitat. Several information sources are available to help identify summer habitats within the home range area:

1. Observations by local residents and agency field personnel.

Table 11. General seasonal habitat descriptions modified from Connelly et al. (2000).

Habitats	General Use Period[1]	General Description[2]
Breeding Habitat	March 1–June 30	Includes leks, prenesting, nesting, and early brood-rearing habitats. A variety of sagebrush plant communities in close proximity to leks and big sagebrush communities.
Summer/Late Brood-Rearing Habitat	July 1–September 30	Variety of mesic or moist habitats in close proximity to sagebrush communities.
Winter Habitat	December 1–February 28 or 29	Variety of sagebrush communities that have sagebrush above the snow.

[1] Use periods may vary based on elevation and annual weather conditions.

[2] General descriptions for some areas; primary vegetation communities may vary based on local conditions and availability.

2. Historic observations in BLM or other agency files.
3. Telemetry data.
4. National Wetlands Inventory (NWI) maps.
5. National Hydrography Dataset (NHD) maps.
6. Riparian proper functioning condition (PFC) assessments and maps.
7. Remote sensing data (NAIP, GAP, Landfire, etc.).
8. Digital elevation models.
9. Current and historic brood survey routes/ area surveys conducted by wildlife agencies.

Mesic sagebrush communities adjacent to breeding habitats should be considered summer habitat and may occur beyond the 18 km distance from leks, particularly in higher elevation areas. In addition, within breeding and summer sagebrush habitat, all riparian, wetland, and other forb-rich habitat should be considered summer habitat. Ground–truthing of historic brood routes should be conducted to determine continued presence of sage-grouse.

Fall Habitat: Fall is the period when sage-grouse transition from feeding on forbs, insects, and sagebrush to primarily sagebrush. Use of fall habitats may occur from September to December due to yearly variability in temperature and precipitation as plants desiccate or die from frost (Connelly et al. 2011). Fall habitats are generally not believed to be a limiting life history component for most populations and therefore are not discussed further.

Winter Habitat: Sage-grouse are entirely dependent on sagebrush for food and cover during winter. Sage-grouse use sagebrush that is exposed above the snow or on windswept ridges. Sagebrush that is covered by deep snow, such as at some higher elevations, is not available to sage-grouse. Sage-grouse typically congregate in large groups during winter and use traditional wintering areas (Berry and Eng 1985; Schroeder and Robb 2003). Wintering areas are likely the most difficult habitats to map for sage-grouse. Wintering areas may be inaccessible, may vary based upon annual weather/snow conditions, or may be found long distances from other known habitats. Mapping known traditional winter use areas, particularly those that are used by large numbers of birds, is important. Due to access constraints during winter, potentially important areas may be identified any time during the year based on topography, sagebrush type, and evidence of roost (pellet group) sites. Areas should eventually be verified for winter use, if possible, by documenting birds, tracks, and scat observed. Particularly during years of above average snowfall, biologists should attempt to document sage-grouse winter-use areas to identify the critical habitat areas. Additionally, biologists should conduct directed searches of likely areas during the winter based upon topography, slope and aspect, elevation, and vegetation. The state wildlife agency, local landowners, or other field personnel may have information regarding winter use. Information sources that may be useful include:

1. Observations by local residents, local working groups, or agency personnel.
2. Telemetry data.
3. Historic observations from land management and wildlife agency files.
4. Aerial flights during winter.
5. Graduate theses, dissertations, and published literature.

Step 3. Describe seasonal habitat availability.

Using the information from steps 1 and 2, describe occupied and potential seasonal habitats in the home range area. Breeding, summer, and winter habitats are important to describe. Calculate:

1. The estimated amounts of occupied breeding, summer, and winter habitats.
2. The estimated amounts of potential breeding, summer, and winter habitats.

Documenting the amount of existing sage-grouse seasonal habitat relative to potential habitat is important because it provides critical information for restoration planning.

Step 4. Describe and map anthropogenic features within and between seasonal habitats.

Overlay spatial data for anthropogenic features that was gathered at the second order (mid scale; indicator 6). For the home range area, document the following information:

1. The location and density of highways, major roads (km/km^2), railroads, transmission lines, oil/gas pipelines, and other large linear features.
2. The location, number, and density (sites/km^2) of communication sites, energy pads, mineral sites, wind turbines, meteorological towers, geothermal sites, landfills, gravel pits, and other anthropogenic features.
3. If planning a habitat trend analysis, the estimated decade or year (the latter if within the last 10 years) when the anthropogenic feature occurred within the home range.
4. The cumulative suitability of the home range based on anthropogenic features.

Step 5. Describe vegetation connectivity characteristics between seasonal use areas.

Home ranges with contiguous sagebrush cover between seasonal use areas are more suitable as habitat than those with discontinuous land cover. For home ranges with separated seasonal use areas, habitat suitability improves as the amount of shrub cover between seasonal use areas increases and tree or annual grass cover decreases. Shrub cover connectivity is particularly important for movements between breeding and summer habitat when chicks are incapable of making long-distance flights. Describe the vegetation between each seasonal use area: breeding to summer, summer to winter, and winter to breeding. Also describe the natural barriers (canyons, mountains) and anthropogenic barriers (reservoirs, canals, major highways, intensive agriculture) between each seasonal use area that may hinder the birds' ability to move between the areas.

Step 6. Summarize the information from steps 3-5 to describe existing third-order habitat suitability of the home range area of interest.

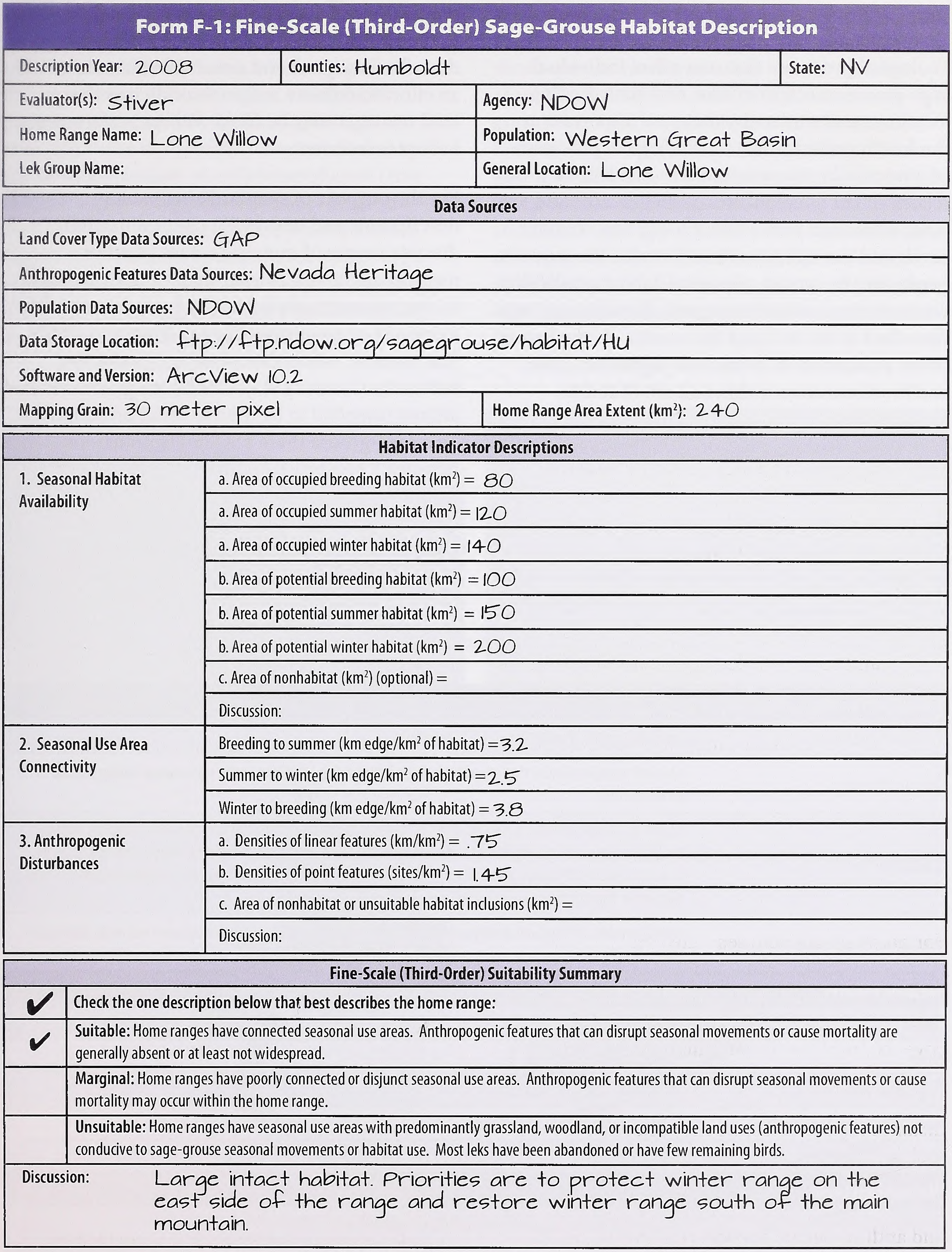
Organize and summarize the information for each third-order indicator on the "Fine-Scale (Third-Order) Sage-Grouse Habitat Description" (form F-1 in appendix B). An example of a completed form for a hypothetical site is shown in figure 12. Baseline third-order habitat data can be used in the future for trend analyses, so documenting the data sources and software, computer programs, and process steps used to describe third-order habitat conditions is important. Identifying where the data for the assessment are stored and can be retrieved in the future is also important. Good documentation of the data, including metadata, and analyses will help future biologists assess changes, causes, and effects.

Once the habitat indicator descriptions have been completed, the suitability of the seasonal-use area can be determined using the descriptive criteria on form F-1.

The habitat suitability of the home range area should be depicted spatially on the map created in steps 1 and 2.

Step 7 (optional). Repeat steps 1-6 and identify a reference period to assess habitat trends.

At the third order, comparing existing habitat suitability data for all or selected indicators to some previous reference period is useful for identifying habitat trends. Land cover type data for the fine-scale indicators of interest as well as sage-grouse lek or other historical data should be available for the reference period. Identify the habitat indicators of interest, measure them with appropriate computer and GIS tools, and describe them in terms of positive, neutral, or negative trends. A summary of this description should be included on form F-1 for each seasonal habitat time period.



Form F-1: Fine-Scale (Third-Order) Sage-Grouse Habitat Description

Description Year: 2008	**Counties:** Humboldt	**State:** NV
Evaluator(s): Stiver	**Agency:** NDOW	
Home Range Name: Lone Willow	**Population:** Western Great Basin	
Lek Group Name:	**General Location:** Lone Willow	

Data Sources

Land Cover Type Data Sources: GAP

Anthropogenic Features Data Sources: Nevada Heritage

Population Data Sources: NDOW

Data Storage Location: ftp://ftp.ndow.org/sagegrouse/habitat/HU

Software and Version: ArcView 10.2

Mapping Grain: 30 meter pixel

Home Range Area Extent (km^2): 240

Habitat Indicator Descriptions

1. Seasonal Habitat Availability	a. Area of occupied breeding habitat (km^2) = 80
	a. Area of occupied summer habitat (km^2) = 120
	a. Area of occupied winter habitat (km^2) = 140
	b. Area of potential breeding habitat (km^2) = 100
	b. Area of potential summer habitat (km^2) = 150
	b. Area of potential winter habitat (km^2) = 200
	c. Area of nonhabitat (km^2) (optional) =
	Discussion:
2. Seasonal Use Area Connectivity	Breeding to summer (km edge/km^2 of habitat) = 3.2
	Summer to winter (km edge/km^2 of habitat) = 2.5
	Winter to breeding (km edge/km^2 of habitat) = 3.8
3. Anthropogenic Disturbances	a. Densities of linear features (km/km^2) = .75
	b. Densities of point features (sites/km^2) = 1.45
	c. Area of nonhabitat or unsuitable habitat inclusions (km^2) =
	Discussion:

Fine-Scale (Third-Order) Suitability Summary

✓	**Check the one description below that best describes the home range:**
✓	**Suitable:** Home ranges have connected seasonal use areas. Anthropogenic features that can disrupt seasonal movements or cause mortality are generally absent or at least not widespread.
	Marginal: Home ranges have poorly connected or disjunct seasonal use areas. Anthropogenic features that can disrupt seasonal movements or cause mortality may occur within the home range.
	Unsuitable: Home ranges have seasonal use areas with predominantly grassland, woodland, or incompatible land uses (anthropogenic features) not conducive to sage-grouse seasonal movements or habitat use. Most leks have been abandoned or have few remaining birds.

Discussion: Large intact habitat. Priorities are to protect winter range on the east side of the range and restore winter range south of the main mountain.

Figure 12. An example of a completed fine-scale (third-order) habitat description form.

Site Scale (Fourth Order)

Ecological processes that may affect individual sage-grouse selection of leks, nest sites, feeding locations, and winter-use areas are important at the fourth order (table 12). Ecological processes of interest take into account seasonal habitat needs related to the life requisites of shelter and food for birds associated with a lek or lek group. Habitat needs and the indicators that describe life requisite needs vary by season. Seasonal habitat availability, connectivity, and anthropogenic disturbances were described at the mid and fine scales. At the fourth order, availability of protective vegetation cover and food resources within seasonal habitats are described.

The basic seasonal habitat suitability matrices developed for the HAF (forms S-2 through S-6 in appendix B) were based largely on Connelly et al. (2000) as a starting point because they used data collected across the species range. However, while Connelly et al. (2000) describe characteristics of *productive* seasonal habitats, generally equivalent to the HAF's "suitable" class, the HAF also describes marginal and unsuitable habitats in an effort to reflect a range of conditions that a land manager may be faced with in performing a habitat assessment.

For the purpose of standardizing habitat descriptions and improving communication, discrete ranges of numeric values or other measurements (e.g., visual shape guide) are used to describe seasonal habitat indicators as suitable, marginal, or unsuitable (Sather-Blair et al. 2000). The numeric values described for productive habitat by Connelly et al. (2000) are guidelines and are not intended to be used as strict prescriptions. To a sage-grouse there may not be much difference between a sagebrush community with 14 percent sagebrush canopy cover and one with 15 percent canopy cover; however, discrete ranges are needed to organize the field information for interpretation.

Table 12. Summary of site-scale (fourth-order) ecological processes (Johnson 1980), mapping features, and management levels for sage-grouse habitat descriptions.

Ecological Processes	
Ecological Time Period	Current to 5 years; average lifespan of sage-grouse
Climatic Processes	Seasonal weather patterns that can affect individual fitness (e.g., excessive spring rains during nesting or early brood-rearing)
Landscape Processes	Fourth-order processes that have short-term consequences on seasonal habitat selection and suitability: natural variation in potential of ecological sites to provide suitable seasonal habitats; herbivory effects on food and shelter habitat needs; human disturbance of birds during critical periods (breeding and wintering); anthropogenic features that increase predation potential during critical periods
Population Processes Habitat Dynamics	Habitat provides for food and shelter needs of the birds for effective daily use within seasonal use areas; individual fitness is sufficient
Mapping Features	
Extent	Seasonal use areas
Grain	Sampling plots (transects)
Vegetation Cover Types	Associations and ecological sites
Geographic Extent Equivalents	Cover type within an ecological site
Cartographic Scale Range	e.g., <1:24,000
Management Levels	
Administrative Hierarchical Level	Grazing allotments, pastures, state wildlife management areas, etc.
Planning and Assessment Documents	Site evaluations; project-specific assessments and plans

Individual indicator values cannot be used independently to describe habitat suitability; rather, site suitability is described using all of the appropriate indicators. For example, the predominant shape of sagebrush plants in an area affects the herbaceous cover needs during the breeding season. A columnar-shaped (tree-shaped) sagebrush plant does not provide the shelter that a spreading-shaped plant provides (figure 13), and an area dominated by this type of sagebrush shape may be of marginal suitability if the accompanying understory has little grass or forb cover. However, in another area of predominantly columnar-shaped sagebrush plants, the presence of abundant grass, forb, or other shrub species cover may make the site suitable as nesting habitat. At another site, shrub and grass cover may be suitable, but the absence of forbs would reduce overall site suitability. These examples illustrate that individual indicator values do not define site suitability in and of themselves and that overall site suitability descriptions require an interpretation of the relationships between all of the indicators and other factors. Professional expertise and judgment are required for these steps.

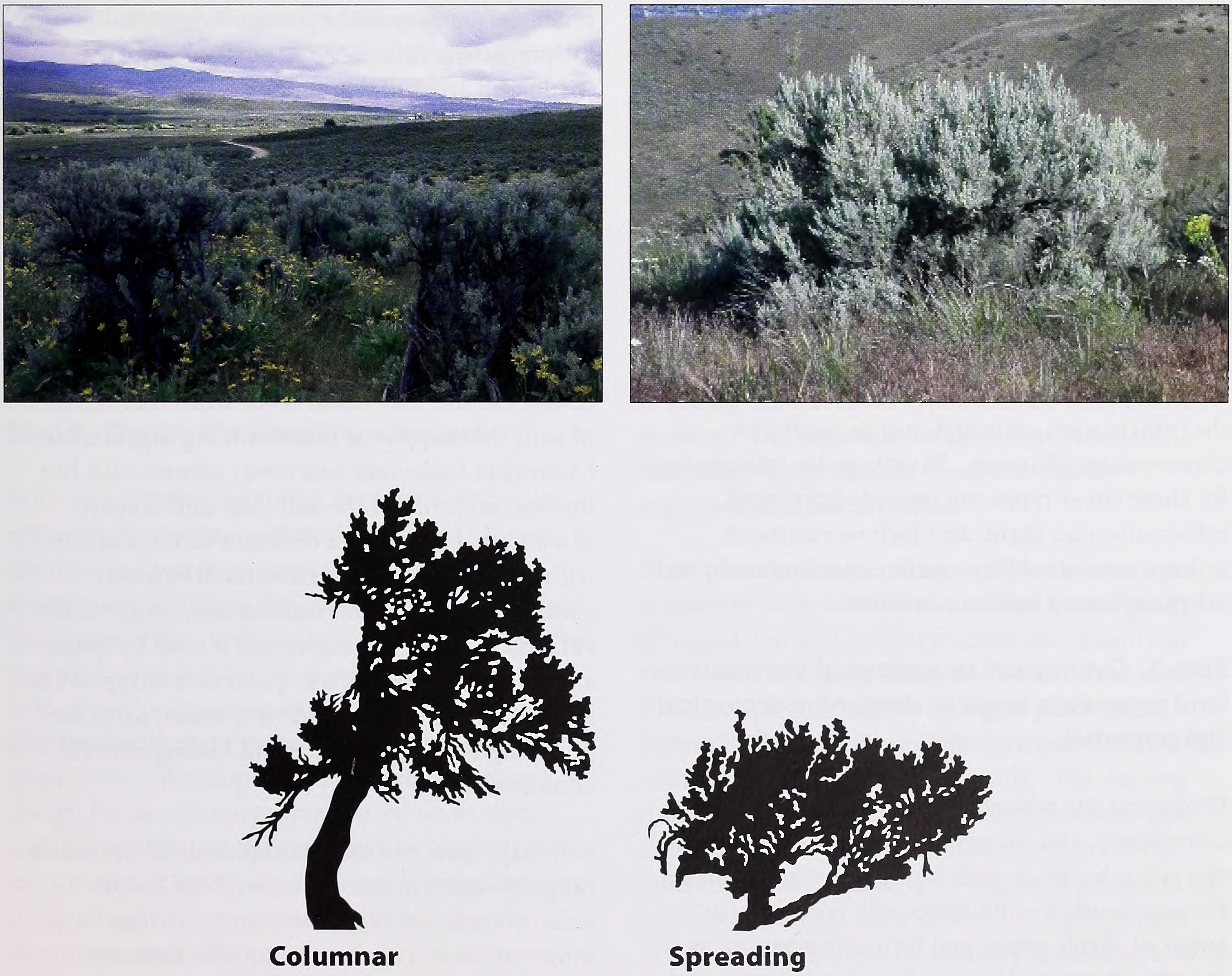


Figure 13. Sagebrush shape is an important habitat cover indicator. Sagebrush communities with more columnar-shaped plants need more herbaceous cover for shelter needs than communities with more spreading-shaped plants.

The steps to describe sage-grouse habitat at the site scale (fourth order) are as follows:

Step 1. Identify seasonal use areas and associated third-order cover types of interest for third-order descriptions. Determine the extent of these land cover types within the seasonal use area.

Refining fine-scale cover type maps of a home range area may be helpful for site-scale descriptions. For a home range area, describing all (e.g., for a small, mountain valley subpopulation) or some (e.g., for a larger, basin subpopulation) of the seasonal use areas may be important. Depending on the scope and purpose of the habitat description, not all land cover types within a seasonal use area may need to be sampled at the project level. For long-term monitoring, only one or two sagebrush cover types for breeding habitat descriptions or certain known wet meadow complexes for brood-rearing habitat descriptions may be needed.

Grasslands or other currently unsuitable cover types that have the potential to become habitat in the future should also be measured because the information collected may be useful for conservation planning. Fourth-order information for these cover types can provide important information on shrub and forb recruitment, linkage area suitability, conifer encroachment, or other aspects of habitat condition.

Step 2. Overlay soil or ecological site maps on land cover type maps to determine ecological site potential.

Ecological site potential, the potential vegetation community, and the production of plant material of a site is based on soil, topography, and climate. For sagebrush communities, site potential (in terms of shrub, grass, and forb composition) is mostly determined by precipitation patterns and soil characteristics (Cronquist et al. 1972; Miller and Eddleman 2001). Ecological site descriptions and soil maps can be obtained from local Natural Resources Conservation Service (NRCS) offices or from the Internet (https://esis.sc.egov.usda.gov). Herrick et al. (2005) provided recommendations on types and numbers of samples as well as background information on ecological sites and site potential. This information is needed for interpreting habitat data for the suitability matrices (e.g., forb abundance related to site potential) and for predicting potential natural habitat changes (i.e., composition and rates of change in community composition relative to natural disturbances and succession) and alternative habitat changes (i.e., composition and rates of change to plant communities not anticipated for a site and from which it is more difficult to recover the natural community). Site potential data would be particularly valuable for predicting future conditions of sagebrush shrubland areas that are now grasslands (native perennial versus exotic annual) due to fire or anthropogenic disturbances.

Soils are mapped in units (e.g., soil mapping units) that can and often do include a mixture of soils correlated to a mixture of ecological sites. For example, a soil map unit may include two soils with two different ecological sites. One ecological site may result from small inclusions of soils that support a mountain big sagebrush (*Artemisia tridentata vaseyana*) community, but the vast majority of the soil map unit consists of a soil that supports a different ecological site with a low sagebrush (*Artemisia arbuscula*) community. These intermixed communities are valuable because big sagebrush is used by males and females for protective cover or nesting, while low sagebrush sites provide important forbs for prelaying hens and broods and loafing sites for adult birds.

Soil maps have not been completed for the entire range of sage-grouse. However, NRCS state soils information is available and provides basic information at a coarse resolution. Data are available at http://www.nrcs.usda.gov/wps/portal/nrcs/site/soils/.

Step 3. Obtain ecological reference sheets, if available, for the ecological sites contained within the seasonal habitat area of interest.

Pellant et al. (2005) described reference sheets as the primary reference for an evaluation of rangeland health. The reference sheet describes a range for each indicator based on expected spatial and temporal variability within each ecological site (or equivalent). Reference sheets provide important information about the 17 indicators of rangeland health and how well the ecological processes are functioning. This information, along with other components of the ecological site descriptions can provide context for more detailed studies on sage-grouse habitat suitability. However, ecological site descriptions have not been completed on portions of the sage-grouse range. If ecological reference areas (ERAs) (Pellant et al. 2005) for the important cover types in the seasonal use area are available, then a visit may be valuable when the expected forb species composition for an ecological site is not well described in ecological site descriptions. Collecting fourth-order data at one or more ERAs for reference purposes might be useful.

Step 4. Design the sampling approach.

Prior to sampling habitat at the fourth order, an appropriate design must be determined. Using the information from steps 1-3, develop an appropriate sampling design and collect field data using one of the methods outlined in the next step and explained further in appendix B. Consulting with other biologists, statisticians, soil scientists, arid land ecologists, or rangeland management specialists to develop an appropriate sampling design for seasonal use areas based on available soils and ecological site data may be helpful. See the Craters of the Moon National Monument case study in appendix A for one example of a sampling approach.

For most fourth-order descriptions, stratified, random sampling of the seasonal habitat area based on land cover types and soils (ecological sites) will be appropriate. In some cases, the seasonal use area may be further stratified by sagebrush canopy cover (e.g., recently disturbed versus mature) or anthropogenic disturbance strata (e.g., grazing pastures, density of anthropogenic features) depending on the intent of the assessment and logistical capacity.

In many areas, patches of big sagebrush (or other tall-statured sagebrush) occur in expansive low or dwarf sagebrush areas. These areas should be treated as two separate cover types or strata. However, there are heterogeneous sagebrush communities that are not easily teased apart and may be better sampled as one stratum. There may be other situations where only certain sagebrush areas are of interest due to steepness of slope, aspect, or other reasons. For example, in “basin and range” topography, seasonal sagebrush habitats may be distributed in narrow, linear stringers adjoining ridges or alluvial fans. In such cases, extra effort is needed to map and stratify these areas to ensure adequate representation in the sample. Use of shorter transects may also be warranted in these situations to ensure that they do not extend beyond the boundary of the cover type of interest. In other cases, only the priority breeding habitat cover types may be sampled due to costs. The rationale for decisions concerning sampling design should always be clearly explained and documented.

Multiple samples (i.e., transects) are likely to be needed in each stratum to account for variability of vegetation and to characterize uncertainty in the habitat indicator estimates. At a minimum, three samples should be collected per stratum because calculating a sample variance per stratum with fewer samples is not possible. The desired number of samples required for each cover type depends on the vegetation heterogeneity of the land cover type and desired degree of precision (or amount of change to be detected). Elzinga et al. (1998) and Herrick et al. (2005) provided guidance on sampling design, and there are many sample size estimation tools available online, including:

> http://www.landscapetoolbox.org/mssret/MSSRET.html

https://www.dssresearch.com/KnowledgeCenter/toolkitcalculators/samplesizecalculators.aspx

Specialists may also want to seek assistance in sample design from a statistician. Ultimately, decisions about the degree of precision and sample sizes should be tempered by what is practical given the budget and time available.

Ideally, sample size requirements should be determined using previously collected habitat data from the study area or from a pilot study. If this is not possible, sample sizes can be estimated by using data collected from nearby, similar areas. When calculating sample sizes, pay attention to specifying realistic degrees of precision, depending on the purpose of the assessment. Some sample size calculators specify precision in terms of percent variation or change from the mean, which can be confusing when specifying precision for proportion or percent cover indicators (e.g., a difference of 10 percentage points for sagebrush cover that is at 20 percent is actually a difference of 50 percent). Variability in a stratum can also vary by indicator. Ideally, sample sizes should be estimated individually for several important indicators such as sagebrush cover, grass height and forb cover, and a sample size that provides sufficient precision for all three should be selected. However, this practice may not be practical in many instances due to logistical realities.

Regardless of the technique used to determine sample size prior to sampling, an evaluation of sampling sufficiency should be conducted at the end of each data collection effort to determine if the data collected meet the stated precision requirements. The same equations and tools used to estimate sample sizes can also be used to assess sample sufficiency. If sample sufficiency is determined to be too low, additional samples may be warranted.

The timing of sampling fourth-order habitat characteristics depends on what is being measured (table 13). Nesting habitat vegetation should be measured toward the end of the nesting period, generally between May 1 and June 30 to assess forb and grass presence, and annual variation in precipitation should be evaluated to determine when samples should be measured. Late brood-rearing habitat should be measured between July 1 and August 30 depending on latitude and elevations. Fall is a transitional time when the birds are moving from summer to winter habitat. During September, birds may still be concentrated on summer use areas where succulent forbs and

Table 13. Seasonal timing of vegetation data collection associated with habitat indicators for site-scale descriptions.

Seasonal Habitat	Window for Vegetation Data Collection	Comments
Breeding (leks)	Anytime	Vegetation data can be collected at any time of year.
Breeding (nesting and early brood-rearing)	April–June	Data should be collected as soon as hens are off the nest (generally May 1–June 30). Timing within this window will vary based on latitude and elevation.
Summer/Late Brood-Rearing	July–August	Data should be collected based on timing of seasonal movements. Data collection for higher elevation late brood-rearing habitat areas should occur later than for areas of lower elevation.
Fall	September–November	See comments under summer season for early fall use areas. As fall progresses, seasonal movements begin and diets shift.
Winter	November–March	Data can be collected at any time in this window. Snow levels may dictate when data should be collected for wintering areas. Consider mapping all sagebrush habitats as a starting point until more use can be verified. Historical and extreme snow depths should be assessed.

insects can be found. As temperatures cool and their diet changes to sagebrush, sage-grouse begin moving from forb-rich areas to winter range. Winter habitat can be evaluated throughout the year as related to sagebrush species and subspecies diversity and general sagebrush distribution on the landscape; however, the availability of sagebrush to sage-grouse in winter (i.e., above the level of snow cover) is contingent on local snow depths. In some cases, therefore, winter site visits are recommended.

Step 5. Collect field data.

Measuring vegetation at the fourth order generally involves collecting field data on composition and structure of habitat within a seasonal use area (table 14). There are additional measurements (e.g., lek proximity to sagebrush) for some seasonal habitats as well. Connelly et al. (2003) described methods that have previously been used to measure sage-grouse habitat at the fourth order. Line intercept and ocular (using a Daubenmire frame) (LIDF) and line-point intercept (LPI) methods can produce different though comparable cover results (Floyd and Anderson 1987; Symstad et al. 2008; Thacker 2010; Santini 2012). True cover parameters are seldom known in natural ecosystems (Bonham et al. 2004). Advantages and disadvantages of each technique are discussed in Elzinga et al. (1998), Connelly et al. (2003), and Bonham (2013). For the HAF, a key objective is that cover averages fall within the appropriate suitability class. Since transect data are averaged and suitability classes are relatively broad, the differences between techniques used to arrive

Table 14. List of seasonal habitat measurements and associated data collection methods. LPI = line point intercept, LIDF = line intercept—Daubenmire frame, PFC = proper functioning condition.

Seasonal Habitat	Habitat Indicator	Life Requisite(s)	Measurement Technique
Lek	Availability of Sagebrush Cover	Cover	Field or remote sensing measurement
	Proximity of Detrimental Land Uses	Security	Field or remote sensing measurement*
	Proximity of Trees or Other Tall Structures	Security	Field or remote sensing measurement*
Breeding	Sagebrush Cover	Cover, Food	LPI/LIDF
	Sagebrush Height	Cover	LPI/LIDF
	Predominant Sagebrush Shape	Cover	LPI/LIDF
	Perennial Grass and Forb Height	Cover	LPI/LIDF
	Perennial Grass Cover	Cover	LPI/LIDF
	Perennial Forb Cover	Cover	LPI/LIDF
	Preferred Forb Availability	Food	Forb diversity transect/plot species inventory
Summer/Late Brood-Rearing – Riparian	Riparian Stability	Cover, Food	PFC data, if available
	Preferred Forb Availability	Food	Forb diversity transect/plot species inventory
	Availability of Sagebrush Cover	Cover	Field or remote sensing measurement
Summer/Late Brood-Rearing – Upland	Sagebrush Cover	Cover, Food	LPI/LIDF
	Sagebrush Height	Cover	LPI/LIDF
	Perennial Grass and Forb Cover	Cover	LPI/LIDF
	Preferred Forb Availability	Food	Forb diversity transect/plot species inventory
Winter	Sagebrush Cover	Cover, Food	LPI/LI (part of LIDF)
	Sagebrush Height (above snow)	Cover	LPI/vegetation height (part of LIDF)

* Proximity of trees, other tall structures, and anthropogenic disturbances to be noted in comment field of data collection forms for all seasonal habitats.

at those estimates should have minimal impact on the end result. Once a technique or multiple techniques are selected, the technique(s) should be used consistently throughout the assessment or monitoring period for future comparability.

For the BLM, the HAF can be implemented in conjunction with the core indicators and methods that were developed as part of the assessment, inventory, and monitoring (AIM) strategy to improve the efficiency and effectiveness of BLM's assessment and monitoring activities (Toevs et al. 2011). The purpose of the core indicators and methods is to provide consistent, quantitative, land cover and vegetation data using standardized measurements that will allow data to be integrated across the entire range of sage-grouse as well as used for other assessment and monitoring purposes (MacKinnon et al. 2011). The core methods were designed to be a minimal set of methods that should be supplemented with additional methods to meet specific resource needs such as sage-grouse habitat assessments or monitoring.

Procedures for the LIDF and LPI data collection methods, including illustrations and data forms, are provided in appendix B. These methods have been used for sage-grouse habitat descriptions across the range of the species.

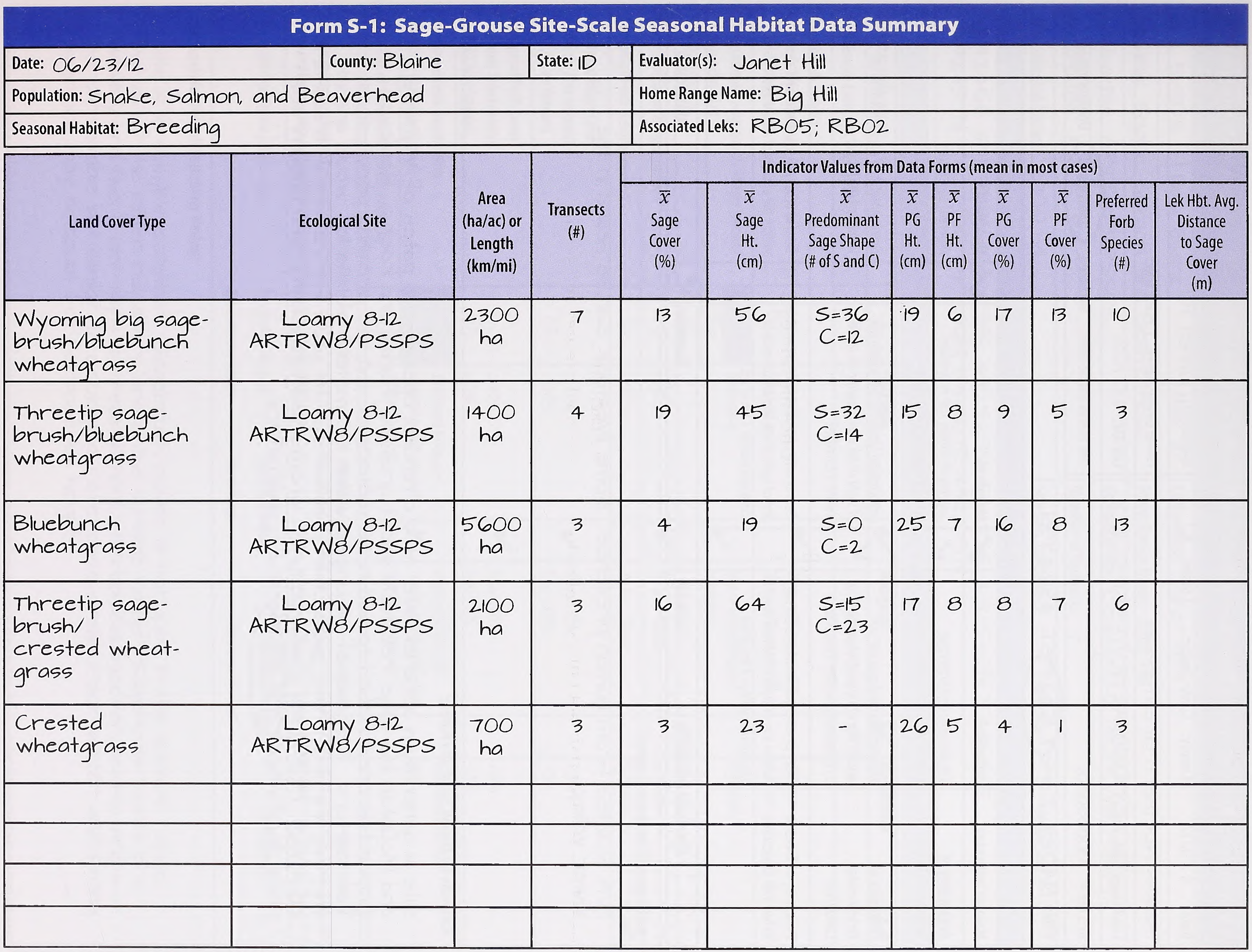
This chapter and appendix B provide instructions and illustrations to aid in the technical aspects of these habitat measurements (e.g., determining sagebrush shape, measuring grass and sagebrush height). Additional fourth-order notes and measurements, including local drought conditions, presence of anthropogenic noise disturbance, other shrub canopy cover (besides sagebrush), annual grass canopy cover, and noxious weed abundance, are addressed for some seasonal habitats to aid in interpreting overall site suitability. For example, sagebrush cover is a crucial habitat indicator for fourth-order descriptions. However, in some locations the composition and percent cover of other shrubs can affect site suitability. For instance, sagebrush may only provide 10 percent canopy cover for a particular cover type, but antelope bitterbrush (*Purshia tridentata*) is also present with a canopy cover of 5 percent. The density of bitterbrush may positively affect the overall site suitability.

Once field data are collected, summarize the data for the seasonal habitats of interest on the "Sage-Grouse Site-Scale Seasonal Habitat Data Summary" (form S-1, appendix B). An example of a completed form for a hypothetical site is shown in figure 14.

Step 6. Transfer field data for land cover types of interest into suitability matrix categories associated with the seasonal habitat. Determine fourth-order suitability.

Once the field data have been summarized for land cover types of interest on form S-1, they can be transferred to the suitability worksheets (forms S-2 through S-7) for the appropriate seasonal use periods. Seasonal habitat suitability worksheets with detailed instructions are provided in appendix B. One worksheet should be completed for each cover type stratum sampled in the seasonal use area and administrative unit (e.g., pasture). Where otherwise similar vegetation cover type strata differ substantially due to slope, aspect, or other factors, summarizing those areas separately may be prudent, depending on local conditions and expertise. The mean, mode, or other appropriate summary statistics for each indicator are recorded on the worksheet, and the corresponding suitability category is checked (✓). Describing overall site suitability requires some level of professional judgment because rarely will all indicators fall in the same suitability range. The rationale for suitability criteria must be explained, particularly if it is not obvious on the worksheet. Examples illustrating suitability interpretations are shown in figures 15 through 18.

Leks (form S-2): Suitability should be described for each lek regardless of status (occupied, unoccupied, or undetermined). Site suitability for leks is relatively easy to describe because there are only two indicators: (1) sagebrush cover (presence and amount of sagebrush in close proximity to

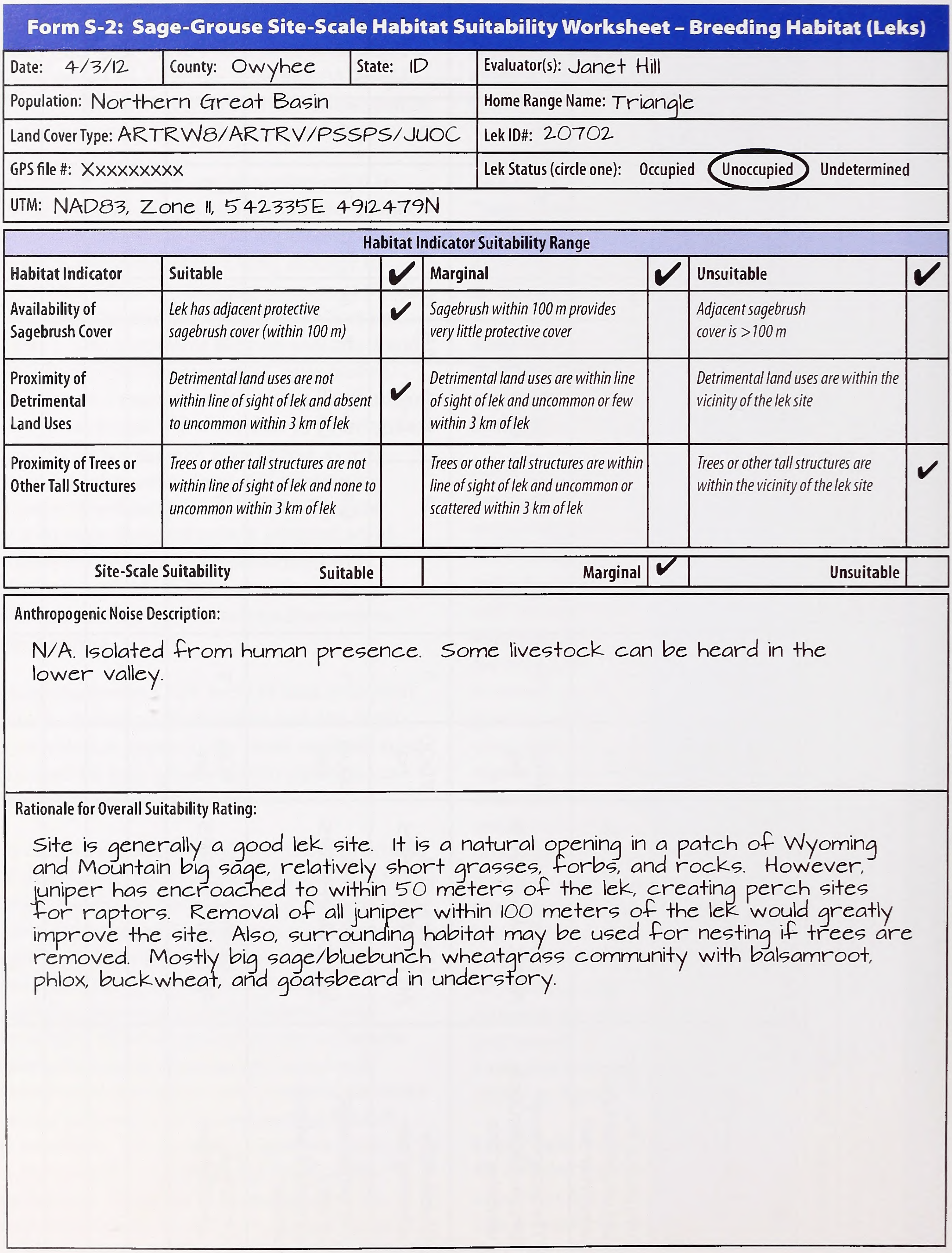


Form S-1: Sage-Grouse Site-Scale Seasonal Habitat Data Summary

Date: 06/23/12
County: Blaine
State: ID
Evaluator(s): Janet Hill
Population: Snake, Salmon, and Beaverhead
Home Range Name: Big Hill
Seasonal Habitat: Breeding
Associated Leks: RB05; RB02

Land Cover Type	Ecological Site	Area (ha/ac) or Length (km/mi)	Transects (#)	Indicator Values from Data Forms (mean in most cases)								
				$\overline{x}$ Sage Cover (%)	$\overline{x}$ Sage Ht. (cm)	$\overline{x}$ Predominant Sage Shape (# of S and C)	$\overline{x}$ PG Ht. (cm)	$\overline{x}$ PF Ht. (cm)	$\overline{x}$ PG Cover (%)	$\overline{x}$ PF Cover (%)	Preferred Forb Species (#)	Lek Hbt. Avg. Distance to Sage Cover (m)
Wyoming big sagebrush/bluebunch wheatgrass	Loamy 8-12 ARTRW8/PSSPS	2300 ha	7	13	56	S=36 C=12	19	6	17	13	10	
Threetip sagebrush/bluebunch wheatgrass	Loamy 8-12 ARTRW8/PSSPS	1400 ha	4	19	45	S=32 C=14	15	8	9	5	3	
Bluebunch wheatgrass	Loamy 8-12 ARTRW8/PSSPS	5600 ha	3	4	19	S=0 C=2	25	7	16	8	13	
Threetip sagebrush/ crested wheatgrass	Loamy 8-12 ARTRW8/PSSPS	2100 ha	3	16	64	S=15 C=23	17	8	8	7	6	
Crested wheatgrass	Loamy 8-12 ARTRW8/PSSPS	700 ha	3	3	23	-	26	5	4	1	3	

Figure 14. An example of a seasonal habitat fourth-order data summary form completed with data from field measurements for the cover types of interest.



Form S-2: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Breeding Habitat (Leks)

Date: 4/3/12	County: Owyhee	State: ID	Evaluator(s): Janet Hill
Population: Northern Great Basin			Home Range Name: Triangle
Land Cover Type: ARTRW8/ARTRV/PSSPS/JUOC			Lek ID#: 20702
GPS file #: Xxxxxxxxx			Lek Status (circle one): Occupied [✓ Unoccupied] Undetermined
UTM: NAD83, Zone 11, 542335E 4912479N			

Habitat Indicator Suitability Range

Habitat Indicator	Suitable	✔	Marginal	✔	Unsuitable	✔
Availability of Sagebrush Cover	*Lek has adjacent protective sagebrush cover (within 100 m)*	✔	*Sagebrush within 100 m provides very little protective cover*		*Adjacent sagebrush cover is >100 m*	
Proximity of Detrimental Land Uses	*Detrimental land uses are not within line of sight of lek and absent to uncommon within 3 km of lek*	✔	*Detrimental land uses are within line of sight of lek and uncommon or few within 3 km of lek*		*Detrimental land uses are within the vicinity of the lek site*	
Proximity of Trees or Other Tall Structures	*Trees or other tall structures are not within line of sight of lek and none to uncommon within 3 km of lek*		*Trees or other tall structures are within line of sight of lek and uncommon or scattered within 3 km of lek*		*Trees or other tall structures are within the vicinity of the lek site*	✔
Site-Scale Suitability	Suitable		Marginal	✔	Unsuitable	

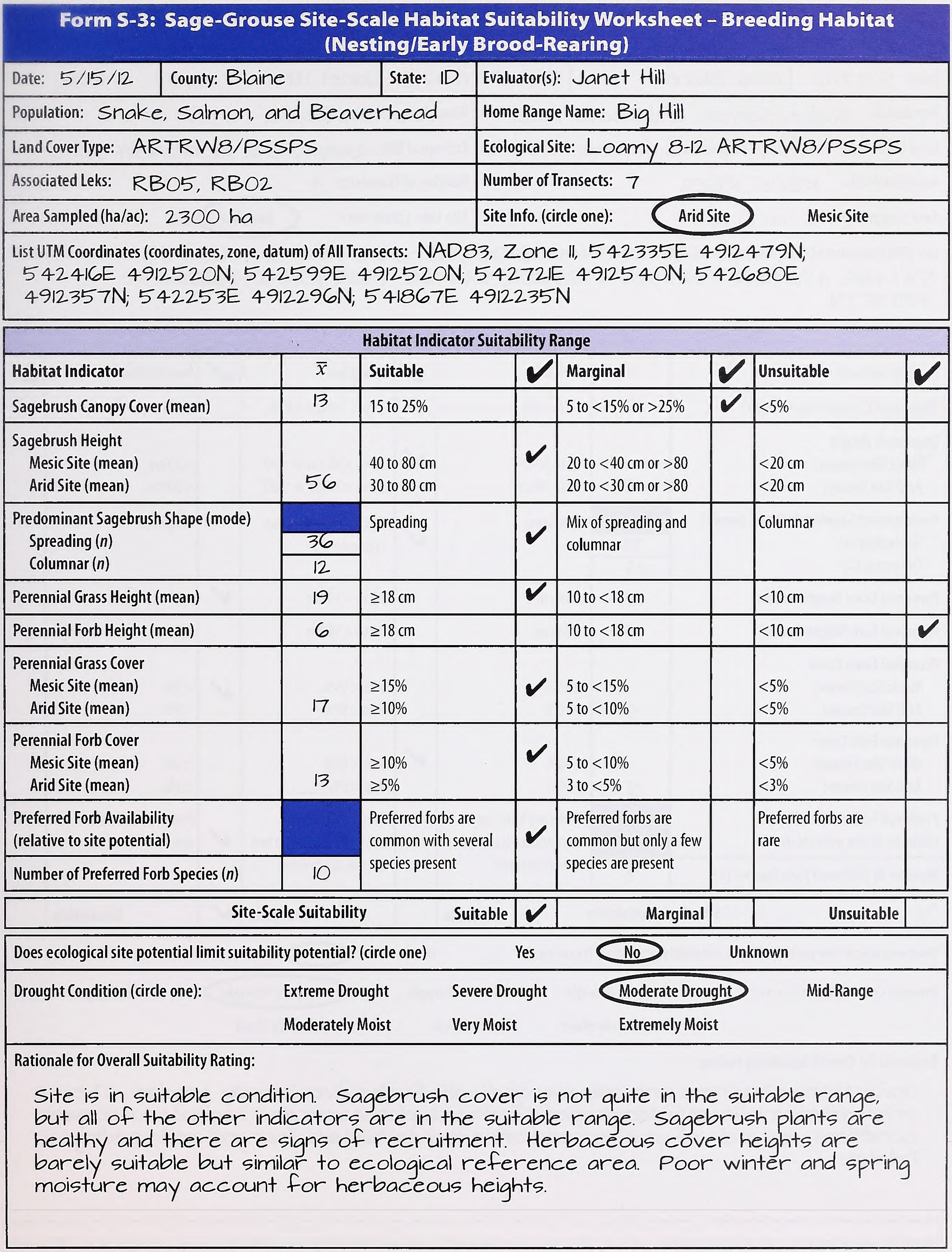
Anthropogenic Noise Description:

N/A. Isolated from human presence. Some livestock can be heard in the lower valley.

Rationale for Overall Suitability Rating:

Site is generally a good lek site. It is a natural opening in a patch of Wyoming and Mountain big sage, relatively short grasses, forbs, and rocks. However, juniper has encroached to within 50 meters of the lek, creating perch sites for raptors. Removal of all juniper within 100 meters of the lek would greatly improve the site. Also, surrounding habitat may be used for nesting if trees are removed. Mostly big sage/bluebunch wheatgrass community with balsamroot, phlox, buckwheat, and goatsbeard in understory.

Figure 15. An example of a completed lek suitability worksheet.



Form S-3: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Breeding Habitat (Nesting/Early Brood-Rearing)

Date: 5/15/12
County: Blaine
State: ID
Evaluator(s): Janet Hill
Population: Snake, Salmon, and Beaverhead
Home Range Name: Big Hill
Land Cover Type: ARTRW8/PSSPS
Ecological Site: Loamy 8-12 ARTRW8/PSSPS
Associated Leks: RB05, RB02
Number of Transects: 7
Area Sampled (ha/ac): 2300 ha
Site Info. (circle one): [✓ Arid Site] Mesic Site

List UTM Coordinates (coordinates, zone, datum) of All Transects: NAD83, Zone 11, 542335E 4912479N; 542416E 4912520N; 542599E 4912520N; 542721E 4912540N; 542680E 4912357N; 542253E 4912296N; 541867E 4912235N

Habitat Indicator Suitability Range							
Habitat Indicator	$\bar{x}$	**Suitable**	✓	**Marginal**	✓	**Unsuitable**	✓
Sagebrush Canopy Cover (mean)	13	15 to 25%		5 to <15% or >25%	✓	<5%	
Sagebrush Height Mesic Site (mean) Arid Site (mean)	56	40 to 80 cm 30 to 80 cm	✓	20 to <40 cm or >80 20 to <30 cm or >80		<20 cm <20 cm	
Predominant Sagebrush Shape (mode) Spreading (*n*) Columnar (*n*)	36 12	Spreading	✓	Mix of spreading and columnar		Columnar	
Perennial Grass Height (mean)	19	≥18 cm	✓	10 to <18 cm		<10 cm	
Perennial Forb Height (mean)	6	≥18 cm		10 to <18 cm		<10 cm	✓
Perennial Grass Cover Mesic Site (mean) Arid Site (mean)	17	≥15% ≥10%	✓	5 to <15% 5 to <10%		<5% <5%	
Perennial Forb Cover Mesic Site (mean) Arid Site (mean)	13	≥10% ≥5%	✓	5 to <10% 3 to <5%		<5% <3%	
Preferred Forb Availability (relative to site potential)		Preferred forbs are common with several species present	✓	Preferred forbs are common but only a few species are present		Preferred forbs are rare	
Number of Preferred Forb Species (*n*)	10						

Site-Scale Suitability	Suitable	✓	Marginal		Unsuitable	

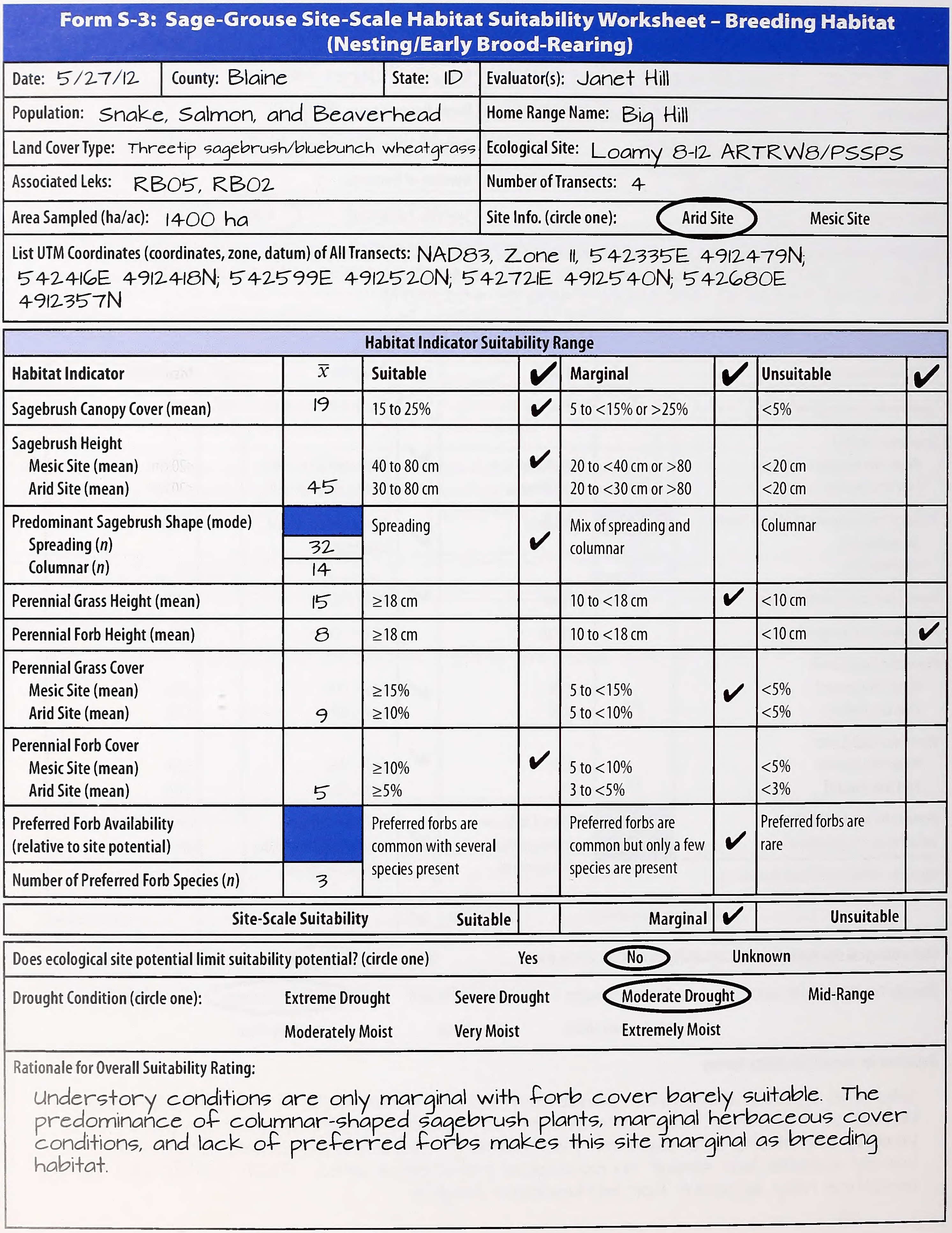
Does ecological site potential limit suitability potential? (circle one) Yes [✓ No] Unknown

Drought Condition (circle one): Extreme Drought Severe Drought [✓ Moderate Drought] Mid-Range Moderately Moist Very Moist Extremely Moist

Rationale for Overall Suitability Rating:

Site is in suitable condition. Sagebrush cover is not quite in the suitable range, but all of the other indicators are in the suitable range. Sagebrush plants are healthy and there are signs of recruitment. Herbaceous cover heights are barely suitable but similar to ecological reference area. Poor winter and spring moisture may account for herbaceous heights.

Figure 16. An example of a Wyoming big sagebrush/bluebunch wheatgrass (*Pseudoroegneria spicata*) cover type with suitable breeding habitat conditions.



Form S-3: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Breeding Habitat (Nesting/Early Brood-Rearing)

Date: 5/27/12	County: Blaine	State: ID	Evaluator(s): Janet Hill
Population: Snake, Salmon, and Beaverhead			Home Range Name: Big Hill
Land Cover Type: Threetip sagebrush/bluebunch wheatgrass			Ecological Site: Loamy 8-12 ARTRW8/PSSPS
Associated Leks: RB05, RB02			Number of Transects: 4
Area Sampled (ha/ac): 1400 ha			Site Info. (circle one): [✓ Arid Site] Mesic Site

List UTM Coordinates (coordinates, zone, datum) of All Transects: NAD83, Zone 11, 542335E 4912479N; 542416E 4912418N; 542599E 4912520N; 542721E 4912540N; 542680E 4912357N

Habitat Indicator Suitability Range

Habitat Indicator	$\bar{x}$	Suitable	✔	Marginal	✔	Unsuitable	✔
Sagebrush Canopy Cover (mean)	19	15 to 25%	✔	5 to <15% or >25%		<5%	
Sagebrush Height Mesic Site (mean) Arid Site (mean)	45	40 to 80 cm 30 to 80 cm	✔	20 to <40 cm or >80 20 to <30 cm or >80		<20 cm <20 cm	
Predominant Sagebrush Shape (mode) Spreading (*n*) Columnar (*n*)	32 14	Spreading	✔	Mix of spreading and columnar		Columnar	
Perennial Grass Height (mean)	15	≥18 cm		10 to <18 cm	✔	<10 cm	
Perennial Forb Height (mean)	8	≥18 cm		10 to <18 cm		<10 cm	✔
Perennial Grass Cover Mesic Site (mean) Arid Site (mean)	9	≥15% ≥10%		5 to <15% 5 to <10%	✔	<5% <5%	
Perennial Forb Cover Mesic Site (mean) Arid Site (mean)	5	≥10% ≥5%	✔	5 to <10% 3 to <5%		<5% <3%	
Preferred Forb Availability (relative to site potential)		Preferred forbs are common with several species present		Preferred forbs are common but only a few species are present	✔	Preferred forbs are rare	
Number of Preferred Forb Species (*n*)	3						
Site-Scale Suitability		Suitable		Marginal	✔	Unsuitable	

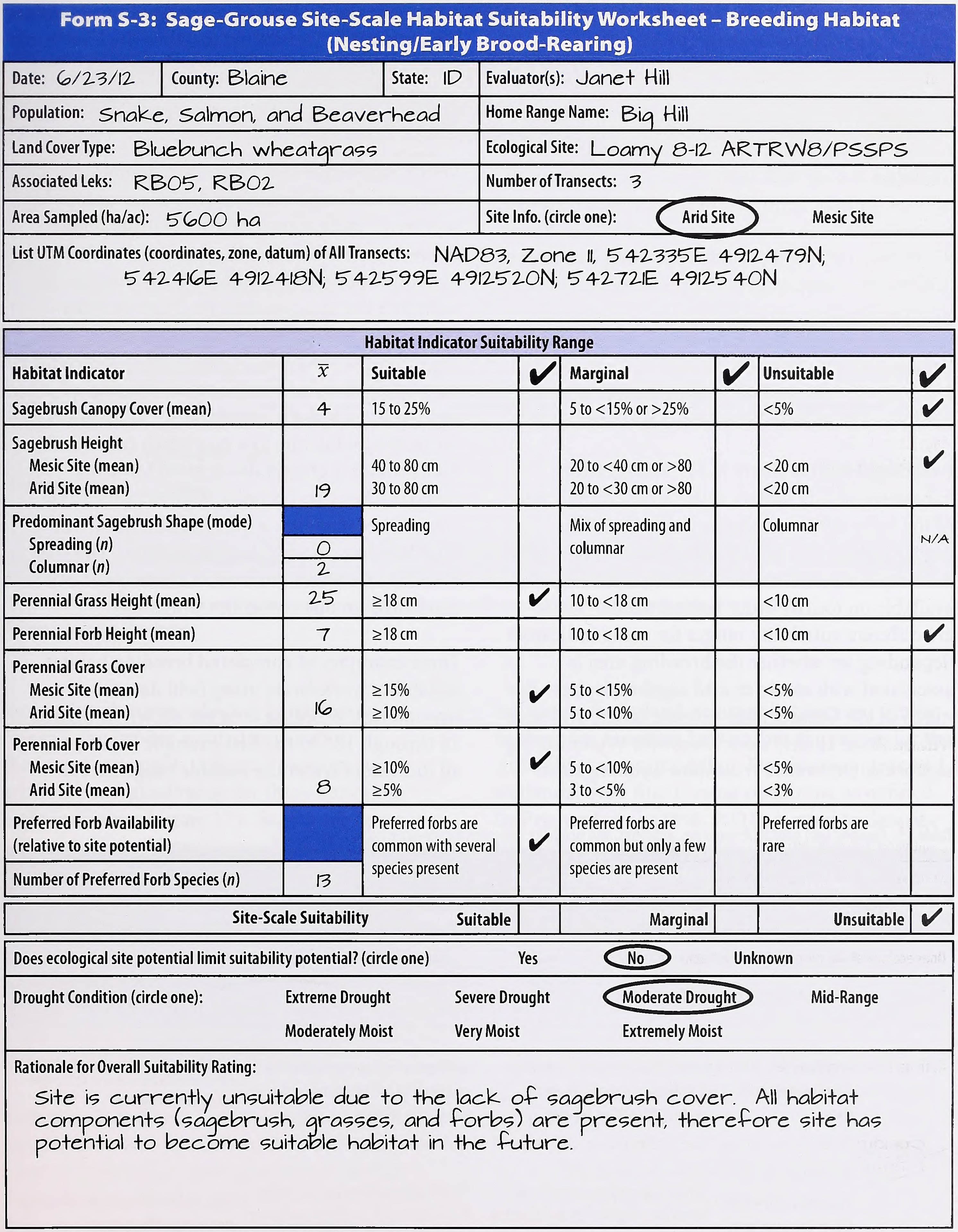
Does ecological site potential limit suitability potential? (circle one) Yes [✓ No] Unknown

Drought Condition (circle one): Extreme Drought Severe Drought [✓ Moderate Drought] Mid-Range Moderately Moist Very Moist Extremely Moist

Rationale for Overall Suitability Rating:

Understory conditions are only marginal with forb cover barely suitable. The predominance of columnar-shaped sagebrush plants, marginal herbaceous cover conditions, and lack of preferred forbs makes this site marginal as breeding habitat.

Figure 17. An example of a threetip sagebrush/bluebunch wheatgrass cover type with marginal breeding habitat conditions.



Form S-3: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Breeding Habitat (Nesting/Early Brood-Rearing)

Date: 6/23/12	**County:** Blaine	**State:** ID	**Evaluator(s):** Janet Hill
Population: Snake, Salmon, and Beaverhead		**Home Range Name:** Big Hill	
Land Cover Type: Bluebunch wheatgrass		**Ecological Site:** Loamy 8-12 ARTRW8/PSSPS	
Associated Leks: RB05, RB02		**Number of Transects:** 3	
Area Sampled (ha/ac): 5600 ha		**Site Info. (circle one):** [✓ Arid Site] Mesic Site	

List UTM Coordinates (coordinates, zone, datum) of All Transects: NAD83, Zone 11, 542335E 4912479N; 542416E 4912418N; 542599E 4912520N; 542721E 4912540N

Habitat Indicator Suitability Range

Habitat Indicator	$\bar{x}$	Suitable	✓	Marginal	✓	Unsuitable	✓
Sagebrush Canopy Cover (mean)	4	15 to 25%		5 to <15% or >25%		<5%	✓
Sagebrush Height Mesic Site (mean) Arid Site (mean)	19	40 to 80 cm 30 to 80 cm		20 to <40 cm or >80 20 to <30 cm or >80		<20 cm <20 cm	✓
Predominant Sagebrush Shape (mode) Spreading (*n*) Columnar (*n*)	 0 2	Spreading		Mix of spreading and columnar		Columnar	N/A
Perennial Grass Height (mean)	25	≥18 cm	✓	10 to <18 cm		<10 cm	
Perennial Forb Height (mean)	7	≥18 cm		10 to <18 cm		<10 cm	✓
Perennial Grass Cover Mesic Site (mean) Arid Site (mean)	16	≥15% ≥10%	✓	5 to <15% 5 to <10%		<5% <5%	
Perennial Forb Cover Mesic Site (mean) Arid Site (mean)	8	≥10% ≥5%	✓	5 to <10% 3 to <5%		<5% <3%	
Preferred Forb Availability (relative to site potential)		Preferred forbs are common with several species present	✓	Preferred forbs are common but only a few species are present		Preferred forbs are rare	
Number of Preferred Forb Species (*n*)	13						

Site-Scale Suitability	**Suitable**		**Marginal**		**Unsuitable**	✓

Does ecological site potential limit suitability potential? (circle one) Yes [✓ No] Unknown

Drought Condition (circle one): Extreme Drought, Severe Drought, [✓ Moderate Drought], Mid-Range, Moderately Moist, Very Moist, Extremely Moist

Rationale for Overall Suitability Rating:

Site is currently unsuitable due to the lack of sagebrush cover. All habitat components (sagebrush, grasses, and forbs) are present, therefore site has potential to become suitable habitat in the future.

Figure 18. An example of a bluebunch wheatgrass cover type with unsuitable breeding habitat conditions. Data indicate that cover type may provide suitable habitat in the future.

the lek); (2) proximity of detrimental land uses; and (3) sage-grouse security (proximity of tall structures such as trees and power poles) (table 15). Describing anthropogenic noise levels (from highways, oil and gas wells, and wind turbines) may also be valuable. Habitat descriptions are intended to help with identifying conservation actions, such as opportunities that might improve the status of a lek. In the example shown in figure 15, removal of avian predator perching structures (e.g., trees, fenceposts) near the lek would likely increase security. In addition, the influence of anthropogenic disturbances on lek use and lekking behavior may be better understood by reviewing how sage-grouse may be using adjacent seasonal habitats (e.g., winter or breeding and nesting).

Breeding Habitat (form S-3): The breeding habitat suitability matrix is the most complicated of the suitability worksheets (table 16). This matrix reflects the importance of breeding habitat, its complexity, and the amount of scientific data available on fourth-order habitat needs. There are different suitability ranges for some indicators depending on whether the breeding area is associated with mesic or arid sagebrush sites. For much of the Greater Sage-Grouse range, arid sites will be those closely associated with Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) and mesic sites will be associated with mountain big sagebrush. Determine whether the land cover type of interest is mesic or arid as defined locally (Connelly et al. 2000) before completing the suitability worksheet.

Where sagebrush cover types are highly interspersed (e.g., small patches of mountain big sagebrush inclusions occurring within a matrix of low sagebrush), sampling patches separately may not be possible or efficient. In such cases, sampling the area as a unit (i.e., one or more transects crossing the mosaic of various cover types) and acknowledging the inherent variability may be the best course of action. The big sagebrush inclusions may provide suitable cover for nesting while the low sagebrush communities may provide a greater diversity of forbs for prelaying hens and broods. Individually, these cover types may lack a life requisite need, but together they provide suitable habitat. The site field data for these intermixed cover types can be combined on one suitability worksheet.

Three examples of completed breeding habitat suitability worksheets using field data for a hypothetical breeding area are shown in figures 16 through 18. In the first example (figure 16), all indicators are in the suitable range except

Table 15. Breeding (lek) habitat life requisites, indicators, and suitability categories for site-scale habitat descriptions.

Life Requisite	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover	Availability of Sagebrush Cover	*Lek has adjacent sagebrush cover (within 100 m)*	*Sagebrush provides very little protective cover adjacent to the perimeter of the lek*	*Adjacent nesting habitat unavailable*
Security	Proximity of Detrimental Land Uses	*Detrimental land uses are not within line of sight of lek and absent to uncommon within 3 km of lek*	*Detrimental land uses are within line of sight of lek and uncommon or few within 3 km of lek*	*Detrimental land uses are within the vicinity of the lek site*
	Proximity of Trees or Other Tall Structures	*Trees or other tall structures are not within line of sight of lek and absent to uncommon within 3 km of lek*	*Trees or other tall structures are within line of sight of lek though uncommon or scattered within 3 km of lek*	*Trees or other tall structures are within the vicinity of the lek site*

Table 16. Breeding (prelaying, nesting, and early brood-rearing) habitat life requisites, indicators, and suitability categories for site-scale habitat descriptions (adapted from Connelly et al. 2000; Sather-Blair et al. 2000; Hagen et al. 2007).

Life Requisite	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover	Sagebrush Cover (%)	*15 to 25*	*5 to <15 or >25*	*<5*
	Sagebrush Height (cm)			
	Mesic Site[1]	*40 to 80*	*20 to <40 or >80*	*<20*
	Arid Site	*30 to 80*	*20 to <30 or >80*	*<20*
	Predominant Sagebrush Shape	*Spreading*	*Mix of spreading and columnar*	*Columnar*
	Perennial Grass and Forb Height (cm)	*≥18*	*10 to <18*	*<10*
	Perennial Grass Cover (%)			
	Mesic[1]	*≥15*	*5 to <15*	*<5*
	Arid	*≥10*	*5 to <10*	*<5*
Cover and Food	Perennial Forb Cover (%)			
	Mesic[1]	*≥10*	*5 to <10*	*<5*
	Arid	*≥5*	*3 to <5*	*<3*
Food	Preferred Forb Availability[2]	*Preferred forbs are common with several species present*	*Preferred forbs are common but only a few preferred species are present*	*Preferred forbs are rare*

[1] Mesic and arid sites should be defined on a local basis; annual precipitation, herbaceous understory, and soils should be considered (Connelly et al. 2000).

[2] Relative to ecological site potential.

for sagebrush cover, which is barely marginal. Overall, the habitat is rated as suitable. In the second example, indicator measurements are in the marginal range for three out of the eight indicators (figure 17). Sagebrush cover is adequate, but understory cover conditions and food resources provide only marginal fourth-order suitability. The last example, which is native perennial grassland, is clearly unsuitable due to lack of sagebrush cover (figure 18). However, native perennial grassland in the breeding habitat area has the ecological potential and the habitat components (i.e., forb and sagebrush recruitment) to become suitable in the future.

Summer Sites (form S-4, upland, and form S-5, riparian): Suitability is described differently for summer/late brood-rearing seasonal habitats depending on whether they are associated with upland sagebrush communities or riparian/wet meadow communities (tables 17 and 18) in close proximity to sagebrush communities. The indicators for upland summer habitats are similar to those for breeding habitat, but the ranges for the suitability categories differ. For riparian areas and wetlands, their functioning condition, as defined by Prichard et al. (1998, 2003), is used to describe site stability, which impacts the likelihood that cover and food resources are provided annually (fourth-order temporal scale). Functioning conditions, though they differ slightly between lentic and lotic areas, are generally defined as follows:

- **Proper functioning condition** (PFC): An area is considered to be in PFC when adequate vegetation or other structure components are present to:
  - Dissipate energy, reduce erosion, and improve water quality.
  - Filter sediment and aid in floodplain development.

Table 17. Summer/late brood-rearing habitat life requisites, indicators, and suitability categories for upland sagebrush site-scale habitat descriptions (adapted from Connelly et al. 2000; Sather-Blair et al. 2000; Hagen et al. 2007).

Life Requisite Feature	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover	Sagebrush Cover (%)	*10 to 25*	*5 to <10 or >25*	*<5*
	Sagebrush Height (cm)	*40 to 80*	*20 to <40 or >80*	*<20*
Cover and Food	Perennial Grass and Forb Cover (%)	*≥15*	*5 to <15*	*<5*
Food	Preferred Forb Availability[1]	*Preferred forbs are common with appropriate numbers of species present*	*Preferred forbs are common but only a few preferred species are present*	*Preferred forbs are rare*

[1] Good abundance, diversity, and availability relative to ecological site potential.

Table 18. Summer/late brood-rearing habitat life requisites, indicators, and suitability categories for riparian or wet meadow site-scale habitat descriptions (adapted from Connelly et al. 2000; Sather-Blair et al. 2000; Hagen et al. 2007).

Life Requisite	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover and Food	Riparian and Wet Meadow Stability	*Majority of areas are in PFC*	*Majority of areas are FAR*	*Majority of areas are NF*
Food	Preferred Forb Availability[1]	*Preferred forbs are common with appropriate numbers of species present*	*Preferred forbs are common but only a few preferred species are present*	*Preferred forbs are rare*
Cover	Availability of Sagebrush Cover	*Sagebrush cover is adjacent to brood-rearing areas (<100 m)*	*Sagebrush cover is in close proximity to brood-rearing areas (100-275 m)*	*Sagebrush cover is unavailable (>275 m)*

[1] Good abundance, diversity, and availability relative to ecological site potential.

  - Improve flood-water retention and ground-water recharge.
  - Stabilize streambanks and shorelines.
  - Develop diverse ponding and channel characteristic for fish and wildlife habitat and other uses.
  - Support greater biodiversity.

- **Functional–at risk (FAR):** An area is considered to be FAR when it possesses some or most of the elements for PFC but has at least one component/process that gives it a high probability of degradation.

- **Nonfunctioning (NF):** An area is considered NF when it clearly lacks the elements listed for PFC.

PFC data are available for most perennial streams and some wet meadows located on federal public lands. There are training opportunities and detailed procedures available for assessing PFC (Prichard et al. 1998, 2003). PFC data should be used whenever possible to help describe sage-grouse habitat. If PFC data cannot be obtained from other sources or collected directly, then the other two indicators should be used to assess habitat suitability.

Forb diversity should be described for brood-rearing areas associated with sagebrush uplands, including those adjacent to agricultural lands (e.g., alfalfa fields). With respect to the latter, descriptions should address whether sage-grouse are exposing themselves to unnecessary risks associated with agricultural fields when forbs are present in the uplands or are taking advantage of the only forbs available. Not all agricultural lands provide good brood-rearing habitat. Certain agricultural practices (e.g., herbicide and pesticide spraying, mowing, use of domestic animals considered to be sage-grouse predators) create risks to sage-grouse survival. Potential risks associated with agricultural fields should be noted (e.g., pesticides (Blus et al. 1989), direct mortality by mower, West Nile virus, etc.).

Proximity to taller sagebrush communities may be an important habitat indicator in some situations. For instance, some brood-rearing habitat occurs in forb-rich, low sagebrush communities adjacent to big sagebrush. In other cases, the available forbs such as arrowleaf balsamroot (*Balsamorhiza sagittata*) may be providing adequate cover, especially for very young broods (≤21 days old).

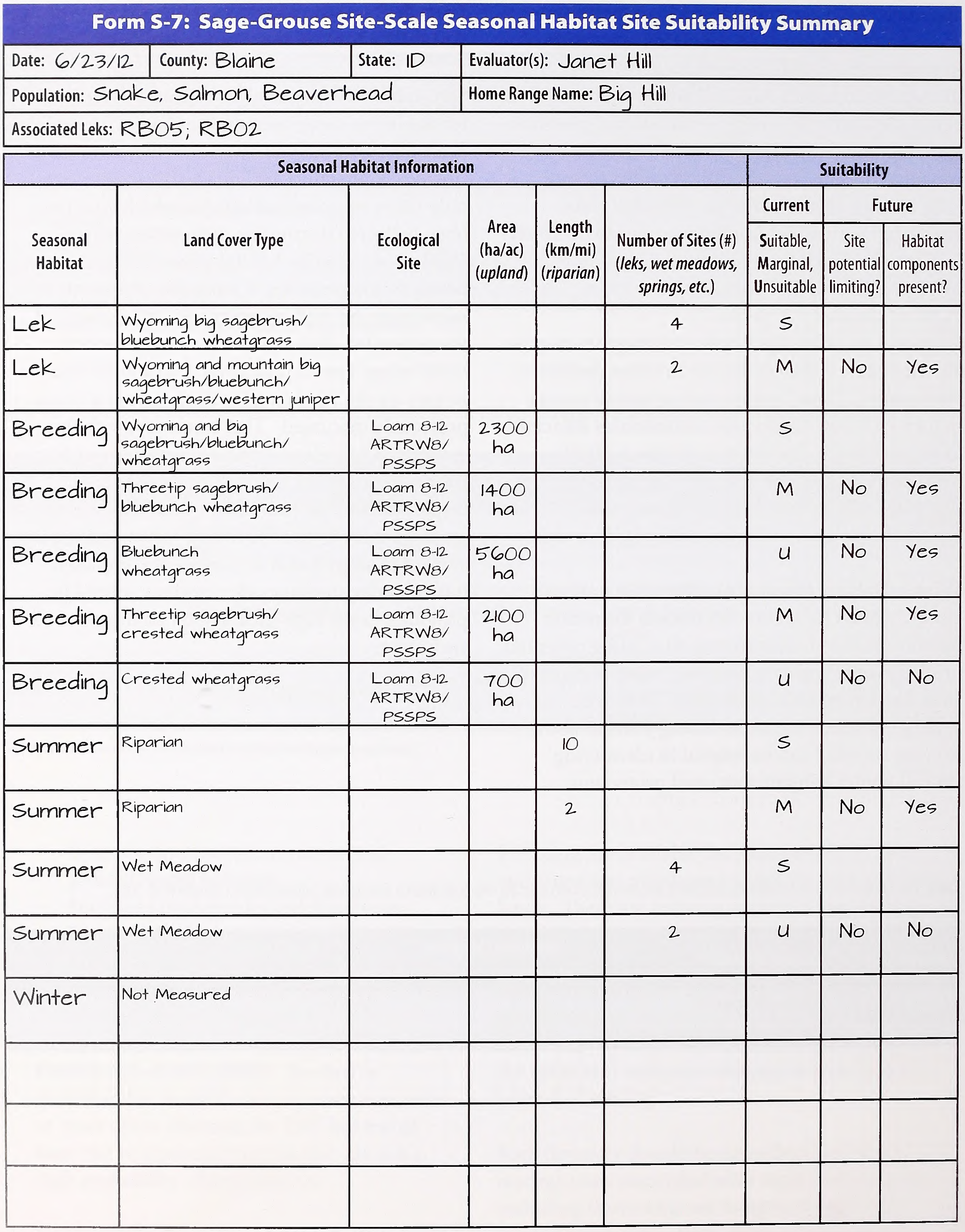
Winter Habitat (form S-6): There are only two closely related indicators of concern for winter habitat (table 19). Identifying all existing potential or likely winter areas is generally more important than describing individual areas. However, evaluating wintering areas during years of above average snowfall can be helpful in identifying critical winter habitats that need protection.

Step 7. Describe fourth-order habitat suitability for the seasonal habitats of interest.

Summarize the seasonal suitability descriptions for the home range area on the "Sage-Grouse Site-Scale Seasonal Habitat Site Suitability Summary" (form S-7, appendix B). Be sure to summarize only those seasonal habitats for which data have been collected during the appropriate season. Further, summarize habitat potential for each area based on the presence of habitat components (e.g., sagebrush and forb recruitment) and ecological site potential. An example for a hypothetical home range area is presented in figure 19 based in part on the field data for the land cover types previously discussed. This summary, with the associated field data, represents a fourth-order habitat description for the home range area. Depict the habitat suitability of the seasonal use areas spatially within the home range on the map created in steps 1 and 2. Copies of completed fourth-order summary descriptions should be provided to the sage-grouse data coordinator for each state.

Table 19. Winter habitat life requisites, indicators, and suitability categories for site-scale habitat descriptions (adapted from Connelly et al. 2000; Sather-Blair et al. 2000).

Life Requisite	Habitat Indicator	Suitability Categories		
		Suitable	Marginal	Unsuitable
Cover and Food	Sagebrush Cover (%)	≥10	5 to <10	<5
	Sagebrush Height (above snow) (cm)	≥25	>10 to <25	≤10



Form S-7: Sage-Grouse Site-Scale Seasonal Habitat Site Suitability Summary

Date: 6/23/12
County: Blaine
State: ID
Evaluator(s): Janet Hill
Population: Snake, Salmon, Beaverhead
Home Range Name: Big Hill
Associated Leks: RB05; RB02

Seasonal Habitat Information						Suitability		
						Current	Future	
Seasonal Habitat	Land Cover Type	Ecological Site	Area (ha/ac) (*upland*)	Length (km/mi) (*riparian*)	Number of Sites (#) (*leks, wet meadows, springs, etc.*)	Suitable, Marginal, Unsuitable	Site potential limiting?	Habitat components present?
Lek	Wyoming big sagebrush/ bluebunch wheatgrass				4	S		
Lek	Wyoming and mountain big sagebrush/bluebunch/ wheatgrass/western juniper				2	M	No	Yes
Breeding	Wyoming and big sagebrush/bluebunch/ wheatgrass	Loam 8-12 ARTRW8/ PSSPS	2300 ha			S		
Breeding	Threetip sagebrush/ bluebunch wheatgrass	Loam 8-12 ARTRW8/ PSSPS	1400 ha			M	No	Yes
Breeding	Bluebunch wheatgrass	Loam 8-12 ARTRW8/ PSSPS	5600 ha			U	No	Yes
Breeding	Threetip sagebrush/ crested wheatgrass	Loam 8-12 ARTRW8/ PSSPS	2100 ha			M	No	Yes
Breeding	Crested wheatgrass	Loam 8-12 ARTRW8/ PSSPS	700 ha			U	No	No
Summer	Riparian			10		S		
Summer	Riparian			2		M	No	Yes
Summer	Wet Meadow				4	S		
Summer	Wet Meadow				2	U	No	No
Winter	Not Measured							

Figure 19. An example of a completed seasonal habitat fourth-order suitability summary that includes information from the previous seasonal habitat worksheet examples.

Glossary

Abundance: The total number of organisms in an area (Wisdom et al. 2003; Braun 2005).

Adaptive Management: An approach to natural resource management that involves identifying areas of scientific uncertainty, devising field management activities as real-world experiments to test that uncertainty, learning from the outcome of such experiments, and revising management guidelines on the basis of the knowledge gained (Morrison et al. 1998).

Adult (sage-grouse): A sage-grouse that is greater than 15 months of age and has entered or is about to enter its second breeding season (Connelly et al. 2003).

Alliance (plant): A physiognomically uniform group of plant associations sharing one or more dominant or diagnostic species, which as a rule are found in the uppermost stratum of the vegetation. Dominant species are often emphasized in the absence of detailed floristic information (such as quantitative data), whereas diagnostic species (including characteristic species, dominant differential, and other species groupings based on constancy) are used where detailed floristic data are available (Reid et al. 2002).

Annual (plant): A plant that completes its life cycle and dies in 1 year or less (Pellant et al. 2005).

Anthropogenic Disturbance: The direct loss or fragmentation of habitat due to human development and increased human activity causing the displacement of individuals through avoidance behavior (Holloran 2005).

Anthropogenic Feature: Any human-caused disturbance on the landscape that results in the direct loss or fragmentation of habitat.

Assessment: The process of estimating or judging the functional status of ecosystem structures, functions, or processes within a specified geographic area at a specific time (United States Department of the Interior 2001).

Association (plant): A plant community of definite floristic composition, uniform habitat conditions, and uniform physiognomy. The association level is differentiated from the alliance level by additional plant species, found in any stratum, which indicate finer scale environmental patterns and disturbance regimes (Reid et al. 2002).

Breeding Habitat: Leks and the sagebrush habitat surrounding leks that are collectively used for prelaying, breeding, nesting, and early brood-rearing activities from approximately March through June (Connelly et al. 2000; Connelly et al. 2003).

Brood (sage-grouse): A hen or group of hens with at least one chick.

Canopy Cover: The percentage of the ground (1) included in a vertical projection of imaginary polygons drawn about the total natural spread of foliage of the individuals of a species (usually used for herbaceous plants), or (2) covered by a projection of the crown, stems, and leaves of the plant onto the ground surface (usually used for shrubs).

Chick (sage-grouse): A sage-grouse up to 10 weeks of age (Connelly et al. 2003).

Community: A set of two or more interacting species, such as members of a trophic web, that live in a particular habitat (Meffe and Carroll 1997).

Condition (vegetation): The ability of a community or ecosystem to function naturally (Wisdom et al. 2005).

Connectivity: The degree to which habitats for a species are continuous or interrupted across a spatial extent. Habitats defined as continuous are within a prescribed distance over which a species can successfully conduct key activities (e.g., effective dispersal distances of seeds or juveniles; mean distances moved for foraging, nesting, and brood-rearing). Habitats defined as interrupted are outside the prescribed distance (Wisdom et al. 2003).

Cover: An indication of the relative amount of shelter or protection provided by all vegetation at a given point; it is normally used to assess nesting habitat (Connelly et al. 2003).

Cover Type: A vegetation classification depicting genera, species, group of species, or life forms of trees, shrubs, grasses, or sedges or a dominant physical feature (e.g., water or rock) or land use (e.g., urban or road) of an area. When a genus or species name is given to the cover type at a broad-scale, it is typically representative of a complex of species or genera with similar characteristics (Wisdom et al. 2000).

Daubenmire Frame: A rectangular frame, 20 x 50 cm, used to estimate canopy cover. The frame has a painted pattern that provides visual reference areas equal to 5, 25, 50, 75, and 95 percent of the plot area (Daubenmire 1959).

Dispersal: Movement of individuals to new living areas, including initial movements from place of birth to first attempted breeding area (natal dispersal) and subsequent movements from one breeding location to another (adult dispersal) (Elphick et al. 2001).

Distribution: The spread or scatter of an organism within its range (Morrison and Hall 2001).

Disturbance: Any relatively discrete event in time that disrupts ecosystem, community, or population structure, and changes resources, substrate availability, or the physical environment (White and Pickett 1985). *See also Anthropogenic Disturbance.*

Droop Height: The height of a grass or forb measured from the ground to the point where the plant naturally bends (maximum natural height). There may be no droop to some plants with relatively short stature (Connelly et al. 2003).

Early Brood-Rearing Habitat: Upland sagebrush sites relatively close to nest sites, typically characterized by high species richness with an abundance of forbs and insects, where sage-grouse hens raise young chicks (<21 days old) (Connelly et al. 2000).

Ecological Reference Area (ERA): Land in which ecological processes are functioning within a normal range of variability and the plant community has adequate resistance to and resilience against most disturbances. This area best represents the potential of a site in both physical function and biological health (Herrick et al. 2005).

Ecological Site: An area of land with a specific potential plant community and specific physical site characteristics, differing from other areas of land in its ability to produce vegetation and to respond to management (United States Department of the Interior 1996).

Ecological Site Description: A description of the soils, uses, and potential of a kind of land with specific physical characteristics to produce distinctive kinds and amounts of vegetation (Pellant et al. 2005).

Ecological Site Potential: The plant community that can be supported in an area given its edaphic and climatic potential (Habich 2001).

Ecosystem: The totality of components of all kinds that make up a particular environment; the complex of a biotic community and its abiotic, physical environment (Wisdom et al. 2005).

Edge: The intersection of two vegetation types (Morrison et al. 1998).

Edge Effect: The influence of a habitat edge on interior conditions of a habitat or on species that use interior habitat (Meffe and Carroll 1997).

Encroachment: Advancement beyond the usual or proper limits; often used to describe the advancement of pinyon pine or juniper woodlands into sagebrush communities (Wisdom et al. 2005).

Erosion: Detachment and movement of soil or rock fragments by water, wind, ice, or gravity (Habich 2001).

Exotic: Not native; an organism or species that has been introduced into an area and is thus outside of its native range (Wisdom et al. 2005).

Extent: (1) [*general*] The area over which observations are made (e.g., study area, species range); (2) [*spatial*] The geographic limits of a geographic dataset specified by the minimum bounding area (Wisdom et al. 2005).

Extirpation: The loss or removal of a species from one or more specific areas but not from all areas (Wisdom et al. 2005).

Fall Habitat: The matrix of sagebrush habitat areas that sage-grouse slowly move through from September through November, transitioning from summer habitat to winter habitat and shifting their diet from large amounts of forbs to exclusively sagebrush (Connelly et al. 2000).

Foliar Cover: The percentage of ground covered by the vertical projection of the aerial portion of plants. Small openings in the canopy and intraspecific overlap are excluded.

Forb: An herbaceous plant other than a grass, sedge, or rush, that has little or no woody material (United States Department of the Interior 1996).

Fragmentation: The process by which a species habitat is reduced and fragmented into pieces separated by areas of unsuitable habitat or nonhabitat. Habitat fragmentation has not occurred when habitat has been separated by unsuitable habitat but occupancy, reproduction, or survival of the species has not been affected (Franklin et al. 2002).

Geographic Information System (GIS): A collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information (ESRI 2006).

Grain: (1) [*general*] The smallest resolvable unit of study (e.g., 1- x 1-m quadrant), which generally determines the lower limit of what can be studied (Morrison and Hall 2001); (2) [*spatial*] The mapping resolution at which spatial patterns are measured (Wisdom et al. 2000).

Grass: Any plant of the family Poaceae (United States Department of the Interior 1996).

Grassland: Vegetation dominated by grasses and grasslike plants, including sedges and rushes (Reid et al. 2002).

Habitat: An area with a combination of resources (such as space, food, cover, and water) and environmental conditions (such as temperature, precipitation, presence or absence of predators and competitors) that promotes occupancy by individuals of a given species and allows those individuals to survive and reproduce (Morrison et al. 1998).

Habitat Indicator: A component or attribute of habitat that can be observed and or measured to characterize suitability for space, food, cover, and water.

Habitat Patch: A species habitat unit, appropriate for the scale of interest, surrounded by unsuitable habitat (adapted from Franklin et al. 2002).

Habitat Quality: A measure of two components: (1) habitat use (selection) by animals, and (2) fitness consequences associated with that habitat (Van Horne 1983; Aldridge 2005; Aldridge and Boyce 2007).

Habitat Selection: The process by which an animal chooses its habitat or habitat components (Johnson 1980). The orders of selection are as follows:

> **First-Order Selection:** Selection of the physical or geographic range of a species.
>
> **Second-Order Selection:** Selection of the physical or geographic home range for a subpopulation (e.g., for a sage-grouse lek or lek group).
>
> **Third-Order Selection:** Selection of seasonal habitats (cover types) within a home range (e.g., sage-grouse seasonal habitat areas).
>
> **Fourth-Order Selection:** Selection of habitat components (food items and shelter provisions for feeding, nesting, and roosting areas) within a seasonal use area.

Habitat Suitability: The relative appropriateness of a certain ecological area for meeting the life requirements of an organism (i.e., space, food, cover, and water). Categories of habitat suitability include:

> **Suitable Habitat:** An area that provides environmental conditions necessary for successful survival and reproduction to sustain stable populations (Cooperrider et al. 1986; Morrison et al. 1998).
>
> **Marginal Habitat:** An area that supports the species but has generally lower survival rates and reproductive success by comparison and may or may not have the potential to become suitable in the future (Cooperrider et al. 1986).
>
> **Potential Habitat:** An area that is currently unoccupied but has the potential for occupancy in the foreseeable future (<100 years) through succession or restoration.
>
> **Unsuitable Habitat:** An area that does not currently provide one or more of the life requisites and therefore does not provide habitat, but it may provide habitat sometime in the foreseeable future (<100 years) through succession or restoration.
>
> **Nonhabitat:** An area within the historical distribution of sage-grouse that is unoccupied, does not currently provide habitat, and does not have the potential to provide habitat in the foreseeable future (<100 years).

Herbaceous (vegetation): Plants that die back to the ground each year, normally with soft, nonwoody stems (Connelly et al. 2003).

Home Range: The area traversed by an animal during its activities during a specified period of time (Morrison and Hall 2001).

Indicator: *See Habitat Indicator.*

Invasive (plant): A plant species that is not part of, or is a minor component of, a predisturbance plant community and that has the potential to become a dominant or codominant species on the site if its future establishment and growth is not actively controlled by management interventions (Pellant et al. 2005).

Inventory: A point-in-time measurement of a resource to determine its location or condition (Elzinga et al. 1998).

Land Cover Type: A classification of the observed biophysical cover on the surface of the earth (Wisdom et al. 2005).

Landscape: A mosaic of landforms, vegetation, and land uses; a heterogeneous land area that is often hierarchically structured and varies in extent with the organism(s) being studied and the purpose for defining a landscape (Urban et al. 1987; Liu and Taylor 2002).

Landscape Matrix: A broad-scale pattern of varied vegetation classes and land uses throughout a region (Urban et al. 1987; Crow 2002).

Late Brood-Rearing Habitat: A variety of habitats used by sage-grouse from July through September, including, but not limited to, wet meadows, farmland, riparian areas, dry lakebeds, and sagebrush areas (Connelly et al. 2000).

Lek: Open area surrounded by sagebrush, without trees or other tall structures in close proximity, where males traditionally display and breeding occurs (Connelly et al. 2000). Categories of leks are as follows:

> **Occupied lek:** (1) [*Greater Sage-Grouse*] A lek that has been active during at least one breeding season within the prior 5 years; (2) [*Gunnison Sage-Grouse*] A lek that has been attended by males in the previous 5 years. Note: The specific terms and definitions for lek status may vary by state. Use the terminology appropriate for your area.
>
> **Unoccupied lek:** (1) [*Greater Sage-Grouse*] A lek that has not been active during a period of 5 consecutive years; (2) [*Gunnison Sage-Grouse*] A lek that has been inactive for 5 years. Note: The specific terms and definitions for lek status may vary by state. Use the terminology appropriate for your area.
>
> **Undetermined lek:** Any lek that has not been documented as active in the last 5 years, but for which survey information is insufficient to designate the lek as unoccupied. Note: The specific terms and definitions for lek status may vary by state. Use the terminology appropriate for your area.

Lek Group: A group of leks with 5-km overlapping or contiguous buffers (Moynahan et al. 2007).

Life Form (plant): Characteristic form or appearance of a species at maturity, such as a grass, forb, tree, or shrub (Habich 2001).

Life Requisite: An item an animal needs to survive, including food, shelter or cover, water (Morrison et al. 1998), and space.

Line Intercept—Daubenmire Frame (LIDF): Two techniques for measuring canopy cover that involves placing a measuring tape between two points and measuring the amount of plant (crown, stems, leaves) that intersects a vertical projection of this line (Canfield 1941). The line intercept technique is used for measuring shrub cover and the Daubenmire frame technique is used for measuring herbaceous cover. *See Daubenmire Frame.*

Line Point Intercept (LPI): A rapid, accurate method for quantifying soil cover, including vegetation, litter, rocks, and biotic crusts (Herrick et al. 2005). The methodology uses a measuring tape, two pins for anchoring the tape, and a straight, small-diameter rod to determine plant cover and composition.

Linkage Area: A land cover type, other than occupied sagebrush shrubland, that sage-grouse frequently use and may move through to another habitat patch. If made into suitable habitat, this area will increase movement between populations and decrease the probability of extinction of the species by stabilizing population dynamics (Gunnison Sage-Grouse Rangewide Steering Committee 2005).

Marginal Habitat: *See Habitat Suitability.*

Monitoring: The collection and analysis of repeated observations or measurements to evaluate changes in condition and progress toward meeting a management objective (Elzinga et al. 1998).

Native (plant): Indigenous to a given place (Wisdom et al. 2005).

Nesting Habitat: Area with protective grass and high lateral shrub cover where hens nest, typically under sagebrush shrubs (Connelly et al. 2000).

Nonhabitat: *See Habitat Suitability.*

Noxious Weed: An unwanted plant specified by federal or state laws as being especially undesirable, troublesome, and difficult to control. It grows and spreads in places where it interferes with the growth and production of desired species (Habich 2001).

Occupied Habitat (sage-grouse): All sagebrush and associated plant communities known to be used by sage-grouse within the last 10 years. Sagebrush areas that are contiguous with areas of known use and that do not have effective barriers to sage-grouse movement from those areas are considered occupied unless specific information exists that documents the lack of sage-grouse use.

Overstory: The upper canopy or canopies of plants, usually referring to trees, shrubs, and vines (United States Department of the Interior 1996).

Patch: *See Habitat Patch.*

Perennial (plant): A plant that has a lifespan of 3 or more years (Pellant et al. 2005).

Population: A collection of organisms of the same species that freely share genetic material (i.e., breed) (Morrison et al. 1998; Braun 2005). *See also Subpopulation.*

Potential Habitat: *See Habitat Suitability.*

Precision: The closeness of repeated measurements of the same quantity (Elzinga et al. 1998; Braun 2005).

Proper Functioning Condition (PFC) Assessment: A consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of riparian-wetland areas (Prichard et al. 2003). Function ratings are as follows:

> **Proper Functioning Condition (PFC):** A riparian-wetland area in which adequate vegetation or other structure components are present to dissipate energy, reduce erosion and improve water quality, filter sediment and aid in floodplain development, improve floodwater retention and ground-water recharge, stabilize streambanks and shorelines, develop diverse ponding and channel characteristics for fish and wildlife habitat among other things, and support greater biodiversity.
>
> **Functional—At Risk (FAR):** A riparian-wetland area that is in functional condition but has at least one attribute or process that makes it susceptible to degradation.
>
> **Nonfunctioning (NF):** A riparian-wetland area that clearly does not provide adequate vegetation, landform, or large woody debris to dissipate energies associated with high flow and thus does not reduce erosion, improve water quality, etc. (Prichard et al. 2003).

Quantitative: Data derived from measurements, such as counts, dimensions, weights, etc., and recorded numerically. Qualitative numerical estimates, such as ocular cover and production estimates, are often referred to as "semiquantitative" (Pellant et al. 2005).

Range: The limits within which an organism lives or can be found (Morrison and Hall 2001).

Range Site: *See Ecological Site.*

Recruitment: The addition of new individuals (typically only breeding individuals) to a population through reproduction (Dinsmore and Johnson 2005).

Reference Period: A period of time during which data were collected at an area that can be chosen to provide a basis or standard for evaluation or comparison of trend over time. *See also Ecological Reference Area.*

Restoration: The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. An ecosystem is recovered or restored when it contains sufficient biotic and abiotic resources to continue its development without further assistance or subsidy (Society for Ecological Restoration International 2004).

Riparian (habitat): An area that is saturated or inundated at a frequency and duration sufficient to produce vegetation typically adapted for life in saturated soil conditions (Prichard et al. 2003).

Risk: The potential or probability of an adverse event (Wisdom et al. 2005).

Road: A linear route declared a road by the owner, managed for use by low-clearance vehicles having four or more wheels, and maintained for regular and continuous use (United States Department of the Interior 2006).

Sagebrush Ecosystem: Arid and semiarid, sagebrush-dominated lands in the western United States and Canada that encompass the approximate boundaries of the historical range of Greater and Gunnison Sage-Grouse (Wisdom et al. 2005).

Scale: The resolution at which patterns are measured, perceived, or represented. Scale can be broken into several components, including grain and extent (Morrison and Hall 2001). For sage-grouse, scales are as follows:

> **Broad Scale:** Entire species range and populations (first-order habitat selection).
>
> **Mid Scale:** Subpopulations (second-order habitat selection).
>
> **Fine Scale:** Seasonal use areas (third-order habitat selection).
>
> **Site Scale:** Seasonal foraging and shelter habitat (fourth-order habitat selection).

Selection: *See Habitat Selection.*

Shrub: A plant that has persistent woody stems and a relatively low growth habit (less than 5 meters tall) and that generally produces several basal shoots instead of a single bole (Pellant et al. 2005).

Shrubland: Vegetation dominated by shrubs that are generally greater than 0.5 m tall and less than 5 m tall and that generally form greater than 25 percent cover, with trees forming less than 25 percent cover (Reid et al. 2002).

Shrub Steppe: Habitats characterized in western North America by woody, midheight shrubs and perennial bunchgrasses; typically arid, with annual precipitation averaging <36 cm (14 in) over much of the region (Wisdom et al. 2003).

Sink Habitat: Habitat in which local mortality exceeds reproductive success and, therefore, the number of individuals occupying the habitat is declining (Meffe and Carroll 1997).

Site: An area of uniform physical and biological properties and management status (Morrison and Hall 2001).

Site Suitability: The suitability of a specific land cover type or other sampling unit in a seasonal use area based on field data collection.

Source Habitat: Habitat in which local reproductive success exceeds local mortality, thus producing an excess of individuals to emigrate to other areas (Meffe and Carroll 1997).

Species: Groups of populations that can potentially interbreed or are actually interbreeding and can successfully produce viable, fertile offspring (Mayr 1969).

Species Composition (plant): The proportions of various plant species in relation to the total in a given area; it may be expressed in terms of relative cover, density, or weight (Habich 2001).

Subpopulation: A portion of a population in a specific geographic location (Morrison et al. 1998). *See also Population.*

Succession (plant): An orderly and predictable process in which vegetation change represents the life history of a plant community, developing to a distinct climax condition (Morrison et al. 1998).

Succulent: Juicy, watery, or pulpy, as the moist stems of cacti (Habich 2001).

Suitable Habitat: *See Habitat Suitability.*

Summer Habitat: The summer or late brood-rearing period from July through August, when hens and chicks use a variety of moist and mesic habitats where succulent forbs and insects are found in close proximity to sagebrush (Connelly et al. 2000).

Trend: The direction of change in ecological status or resource value rating observed over time (Herrick et al. 2005).

Understory: Plants growing beneath the canopy of other plants; usually refers to grasses, forbs, and low shrubs under a tree or shrub canopy (United States Department of the Interior 1996).

Unsuitable Habitat: *See Habitat Suitability.*

Upland (habitat): An area that is not inundated with water and typically supports vegetation types adapted to life in nonsaturated soil conditions (Prichard et al. 2003).

Watershed: A group of streams that flow into a subbasin (Wisdom et al. 2000).

Wet Meadow: A meadow where the surface remains wet or moist throughout the summer, usually characterized by sedges and rushes (United States Department of the Interior 1996).

Winter Habitat: Sagebrush habitats that provide access to sagebrush above the snow for all food and cover requisite needs (Connelly et al. 2000).

Woodland: Vegetation dominated by open stands of trees with crowns not usually touching (generally forming 25-60 percent cover); canopy tree cover may be less than 25 percent in cases where it exceeds shrub, dwarf-shrub, herb, and nonvascular cover, respectively (Reid et al. 2002).

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Appendix A: Craters of the Moon National Monument Case Study

General Overview

The project area is located on the central Snake River Plain and encompasses nearly 300,000 acres of BLM lands within the Craters of the Moon National Monument (CRMO). Private and state lands are interspersed throughout the area, but do not significantly affect the continuity of the landscape. Shrub cover types are generally Wyoming big sagebrush, antelope bitterbrush, or threetip sagebrush at the lower elevations and mountain big sagebrush at higher elevations. Predominant native perennial understory grasses vary between Thurber's needlegrass, needle-and-thread grass, bluebunch wheatgrass, and Idaho fescue. Roughly two-thirds of the transect sites that were read have been exposed to wildfires in the past 20 years, including 2012 fires that burned 42 sites, and have been treated with a mix of native and nonnative seedings. Roughly one-third of the sites read have greater than 30 percent cover of cheatgrass, although some of those areas are also dominated by sagebrush overstory that could still be important to Greater Sage-Grouse, such as during the winter. The area is habitat for several big game species, raptors, and sagebrush obligates such as Greater Sage-Grouse. The primary land uses are grazing and recreation.

Site Stratification

Prior to the field season, the CRMO interdisciplinary (ID) team developed objectives related to the assessment that would help inform future management decisions. The key questions were "What is the status of Greater Sage-Grouse habitat in the CRMO area?" and "How do we stratify this to answer the questions of habitat suitability compared to current management and site potential?" Objectives were also developed to assist with setting parameters for site stratification. These objectives were to quantify the status of Greater Sage-Grouse in the CRMO by ecological site, pasture, and seasonal habitat designation; determine compatibility between assessment, inventory, and monitoring (AIM) program core indicators and the HAF; and establish locations for long-term monitoring of sage-grouse habitat.

Stratification was completed by the Jornada Experimental Range, New Mexico State University, Las Cruces, using ArcGIS Spatial Analyst. Initially, the current status of spatial and tabular data was determined, and then a boundary for the spatial extent of the study area was defined. Based on the existing data, several parameters were selected for use including existing vegetation, past land treatments, wildfires, and ecological sites. The ecological sites were grouped by similar environmental conditions (e.g., ARTRW8/FEID and ARTRW8/ACTH7) to reduce the number of units needing sampling from 38 to 10. Ecological sites reflect similarities that can be related to the state and transition models, expected potential, and expected vegetation for the site. Allotment and pasture boundaries were used as the analysis unit. A travel management plan had recently been completed, so the official roads and trails layer was used to determine a strategy for getting to sites. The range improvements layer was used to determine potential conflicts prior to field verification to ensure transects avoided structures such as water troughs. The transect locations were reviewed preliminarily and appeared to be well distributed across the study area, and only rarely did they occur in the middle of a reservoir, sheep bed ground, or lava flow. These locations were later omitted. A total of 328 transect locations were identified; of those, 316 were read in 2012.

Field Verification

Although a reliable set of GIS layers was available for the stratification process and GPS was used to navigate to sites, there was still a margin of error as to where the transect sites actually occurred on the ground. Therefore, after sites were selected, field verification that the study sites actually occurred within the correct vegetation and ecological site was necessary. The ID team created a common set of rules for initial site verification. These rules were set prior to field work and were used to determine if the site should be kept, moved, or removed.

- The standard azimuth for transects is 0° (due north).
- If a 0° azimuth causes the transect to cross two or more ecological sites or a nonnatural land cover type (e.g., a road), a random azimuth is then selected for the transect. Sites should not be excluded because they are close to these features, only because the feature itself actually occurs in the transect.
- If the first randomly selected azimuth does not successfully reorient the transect in the target ecological site and vegetation, then the site should be moved 100 meters in a standard direction and selection of random azimuths should not be continued.
- If the site cannot be reoriented or moved due to the shape or size of the target area, then the transect is removed from consideration and a backup transect is selected.
- If accessing the site is dangerous or not possible, then the site is removed and a backup is selected.
- If a site can be moved, move 100 meters into the correct ecological site. If that is not possible, then remove the site and use a backup.

General information regarding how to update the GPS data files used during site verification to reflect any changes to the location, azimuth, ecological site, land cover type (LCT), and general site conditions was also included in the strategy.

The site information worksheet was filled out by the journeyman-level specialist who completed the transect verification. Transects were removed if they landed directly on lava fields, if major anthropogenic disturbances were present (e.g., two power lines and two roads running directly through the site), or if one ecological type was not maintained for the whole transect.

Technicians were able to follow directions laid out during site verification by the specialists and immediately begin data collection. This technique prevented confusion or inconsistency of interpretation by the technicians and removed the burden of determining suitable transect locations. Verifying sites ahead of time also ensured that the specialists were familiar with existing conditions when later reviewing large amounts of data and making habitat suitability decisions from the data. Part of the verification process was to determine if the correct ecological site description (ESD) was represented at the site and to initially confirm the LCT. The LCT was later verified by the line-point intercept (LPI) data. This data is critical for proper grouping of transects when summarizing and assigning a habitat suitability rating.

Protocols for data collection and compilation, naming conventions, and download processes were also established. These protocols ensured that the file structure was widely understood and common threads between field data, processed data, and final data were maintained. Forms were completed in both digital and hard copy format, due to computer program availability issues in the field. No matter what method users select, completed photo cards and photos for each transect provide a simple way to organize hard-copy data, document site completion dates, and verify general information. A GIS specialist created an inclusive data dictionary for the GPS units that were used to collect miscellaneous information, such as range improvements, noxious weed locations, and incidental wildlife and rare plant observations.

Field Data Collection

Initial test sites were read by an ID team to determine the necessary equipment and the methods to implement and to simplify training for technicians. The line intercept—Daubenmire frame method (LIDF) was compared to the line-point intercept (LPI) method for measuring cover by taking 1 week to conduct both techniques at each of the transects completed. The data was subsequently analyzed, and the ID team determined the LPI was the more efficient method, relative to the project area and objectives, because it is the more rapid method for collecting cover data by species and the ground cover data collected is more readily compared to existing range program data. However, if only collecting life form data, the LIDF is the more rapid method. The belt transect, used to document forb species presence, was an adequate method to determine diversity and abundance, but has since been revised. The LIDF method also excels in capturing forb information due to the use of a frame rather than a cover pin.

Seasonal technicians performed most of the data collection. Altogether, there were seven technicians, split into three crews. One technician was designated as the crew lead, and one was responsible for handling data downloads and organization. The technicians had backgrounds in botany, wildlife, and range ecology. With this education and experience, the technicians had an understanding of what was asked and why and had enough interest in what was being collected to ask solid questions that helped improve the process.

Crews were assigned areas to focus efforts into a more logical approach across the analysis area. Two crews were stationed at outlying fire crew guard stations to help reduce drive times, and one crew was based out of the field office. This crew was able to pick up the outlier sites that did not fit in logistically with the other crew locations. Each crew was given a separate set of USGS 1:24k topographic maps that strategically divided the sites to facilitate the most expedient completion of the fieldwork. Habitat type and elevation/precipitation gradients (lowest/driest to highest/most moist) was used to seasonally prioritize the sites. A few nights were spent in the field, and as the season progressed, the terrain became more rugged, increasing the hiking time tremendously. Some of the sites took 2-3 hours to hike into, while others were only a 5-minute walk. However, time spent at each LPI transect was consistently about 1 hour.

Analysis and Reporting

After the field data was collected, it was compiled into the correct format to combine transect data for the appropriate site. From this data, the team derived values for sagebrush shapes, heights, species, perennial grass and forb species height and cover percent, and forb abundance. The ID team made the final determinations of habitat suitability for each site based on the compiled data. The ID team had a good understanding of what to expect from the data, having participated in the earlier field verification, and could identify if anything was missed in the initial collection effort, what should be added to the measurements, which sites to revisit, and which transects should be combined with other transects. Data verification by an ID team is an important step to double check the field data and ensure that no sites were misclassified.

The ID team used telemetry data, field observations, and professional knowledge and judgment to determine the habitat suitability for each site area, in addition to the transect/field data collected. Aspect, slope, elevation, ESDs, past land uses, and disturbance regimes were incorporated into the process. The Excel spreadsheets used to collect field data were imported into an Access database, allowing mass calculations and creating a format that assigned values to each transect and that was compatible with ArcMap for spatial analysis. Joining the tables in ArcMap allows for a completely new level of spatial analysis and display. For example, shrub canopy cover can be displayed for all species/subspecies across the project area. Percent cover, dominant sagebrush species, sagebrush cover only, or percent cover for every shrub except sagebrush are a few examples of data that can be readily displayed. This format also helps display connectivity and distribution of habitat qualities.

Summaries were created using the Access tables joined in ArcMap to ensure the correct spatial attributes such as proper management unit, county, subpopulation, seasonal habitat, and proximity to leks and lek status. These tables were then exported to an Excel workbook and put into a pivot table to simplify data analysis. This process allowed for more rapid and efficient determination of Greater Sage-Grouse habitat suitability of the sites and was compiled using the seasonal habitat data summary (form S-1).

Recommendations and Lessons Learned

As with any process, several items were identified as the assessment progressed that might help simplify and streamline future endeavors:

- If using the LPI instead of the LIDF method, collect the shape of each sagebrush plant encountered along the transect when conducting a separate line intercept for sagebrush cover. This process will expand the number of sagebrush shape samples recorded, especially when there are few plants from which to determine shape.
- Create a general plant species list when completing site verification to prepopulate electronic data forms and facilitate data collection in the field.
- Use of electronic platforms is a more rapid and efficient way to collect information, if only for the ease of processing data later, correcting misspellings, and identifying unknowns. Electronic data management also reduces the amount of paper to file and store. Unfortunately, the requested field tablets were not available until August, so a large amount of the initial data was collected on either GPS units loaded with data dictionaries or on hard-copy forms. The small screen of the GPS units made it difficult to collect forb belt transect and LPI data, but collecting the LPI and LIDF data required about the same amount of time via either hard copy or GPS units. The field tablet screens are roughly the same size as a sheet of paper and accelerate the process.
- Print and store final copies of the transect data. The final version should be clean of errors, easy to read, and organized similarly to the digital formats.
- Plan ahead and create a realistic timeframe and calendar, allowing for training days, prep and closeout time, actual field days, and possible extraneous circumstances (e.g., flat tires, GPS unit malfunctions, wildfires).
- Take time at the beginning of the season to clarify details with resource specialists, both in the field and in the office, prior to field crews starting. This step allowed specialists to have most of our questions answered, so that we could explain the process and needs to the crews.
- Have the specialists spend time in the field with the seasonal crews for training.
- Switch crew members around to make sure each crew maintains similar procedures and perform quality checks at sites.
- The HAF consists of metrics that can be expanded upon to inform more than sage-grouse habitat suitability. The stratification used is consistent with other management objectives and resource needs such as:
  - Documenting invasive annuals and noxious weed presence.
  - Verifying dominant land cover type and plant community with the cover data.
  - Informing land health standards.

Appendix B: Data Forms and Measurement Techniques

This appendix to the sage-grouse HAF contains the data forms for the habitat assessment and specific instructions for completing them. It is organized by scale and is intended to be used in the field or in the lab as appropriate for data collection or summary. Chapter II of the HAF provides the detailed habitat description steps to guide setup and data collection.

Assessments for the broad-scale (first-order) habitat selection require rangewide coverage and policy decisions at either the rangewide scale or the management zone scale. No structured data forms are required for a first-order assessment. Policies establish the management direction for sagebrush habitats and sage-grouse.

The assessment of mid-scale (second-order) habitat selection requires a general delineation of sage-grouse populations, habitat, and habitat patterns such as patch connectivity, linkage, patch edges, and fragmentation. Scientists employing advanced mapping technology will provide decisionmakers with the existing land cover classification (e.g., urban, agriculture, and natural vegetation communities at the alliance level), ecological potential for cover classes, and biotic risk factors across the landscape. Spatial analysts, specializing in anthropogenic features, will add sociological and political layers of constraints on the landscapes. This information will enable managers and decisionmakers working in concert with scientists to describe existing conditions. This assessment can aid in the development of priority conservation focus areas. A single form (form M-1) is required for summarizing the second-order assessment. This form should be applied for each landscape/population assessed at this scale.

Fine-scale (third-order) habitat selection analysis allows managers to plan and implement conservation actions that promote the objectives of the higher level decisions and policies. Managers can also use fine-scale data collected on a single form (form F-1) to develop project priority lists based on science and available spatial analytical information. Priority conservation focal areas can then be identified and evaluated for potential fourth-order treatments. Following this evaluation, specific projects or other actions can then be proposed.

The remainder of the data forms found in this appendix are site-scale (fourth-order) instruments, adequate to describe vegetation communities to the plant association. The forms include detailed directions and illustrations for measuring vegetation at the site scale. Supplemental information regarding vegetation species and preferred forbs for sage-grouse can be found in table B-1 at the end of this appendix. Managers and resource specialists will find systematic collection and analysis of these data helpful in prescribing appropriate actions or treatments for fourth-order projects.

These forms are available as workbook spreadsheets that can be loaded onto field tablets or ruggedized laptop computers. They can be found on the enclosed flash drive and online at the BLM Library website at www.blm.gov/wo/st/en/info/blm-library/publications/blm_publications/tech_refs.html.

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Mid-Scale (Second-Order) Data Forms

Form M-1: Mid-Scale (Second-Order) Sage-Grouse Habitat Description

Date:	Counties:	State:
Evaluator(s):	Populations:	
General Location:	Map File Name:	
Sage-Grouse Management Zone(s):		
Agencies:		

Data Sources

Land Cover Type Data Sources:	Date:
Anthropogenic Features Data Sources:	
Population Data Sources:	
Data Storage Location:	
Software and Version:	
Mapping Grain (spatial resolution):	Population Area Extent (km^2):

Habitat Indicator Descriptions

1. Habitat Availability	a. Area of occupied habitat (km^2) =
	b. Area of potential habitat (km^2) =
	c. Area of nonhabitat (km^2) (optional) =
	Discussion:
2. Patch Size and Number	a. Mean size of occupied habitat patches (km^2) =
	b. # of occupied habitat patches =
	Discussion:
3. Patch Connectivity	Mean distance to nearest occupied habitat patch (km) =
	Discussion:
4. Linkage Area Characteristics	a. % suitable land cover types in linkage areas =
	b. % marginal land cover types in linkage areas =
	c. % unsuitable land cover types in linkage areas =
	Discussion:
5. Landscape Matrix and Edge Effect	a. Mean % positive patch edges =
	b. Mean % negative patch edges =
	Discussion:
6. Anthropogenic Disturbances	a. Densities of linear features (km / km^2) =
	b. Densities of point features (sites / km^2) =
	c. Area of nonhabitat or unsuitable habitat inclusions (km^2) =

Mid-Scale (Second-Order) Suitability Summary	
Landscape Desciption: Check the one description below that best describes the population and subpopulation area:	✓
Suitable: Landscapes have connected mosaics of sagebrush shrublands that allow for bird dispersal and migration movements within the population or subpopulation area. Anthropogenic disturbances that can disrupt dispersal or cause mortality are generally not widespread or are absent.	
Marginal: Landscapes have patchy, fragmented sagebrush shrublands that are not well connected for dispersal and migration in portions of the population or subpopulation area. Anthropogenic disturbances that disrupt dispersal or cause mortality are present throughout all or portions of the landscape. Some lek groups or subpopulations are isolated or nearly isolated.	
Unsuitable: Landscapes were former shrubland habitat now converted to predominantly grassland or woodland cover or other unsuitable land cover or use. Remaining sagebrush patches are predominantly unoccupied or have few remaining birds. Portions of the population or subpopulation area may become occupied in the foreseeable future through succession or restoration.	
Discussion:	

Fine-Scale (Third-Order) Data Forms

Form F-1: Fine-Scale (Third-Order) Sage-Grouse Habitat Description

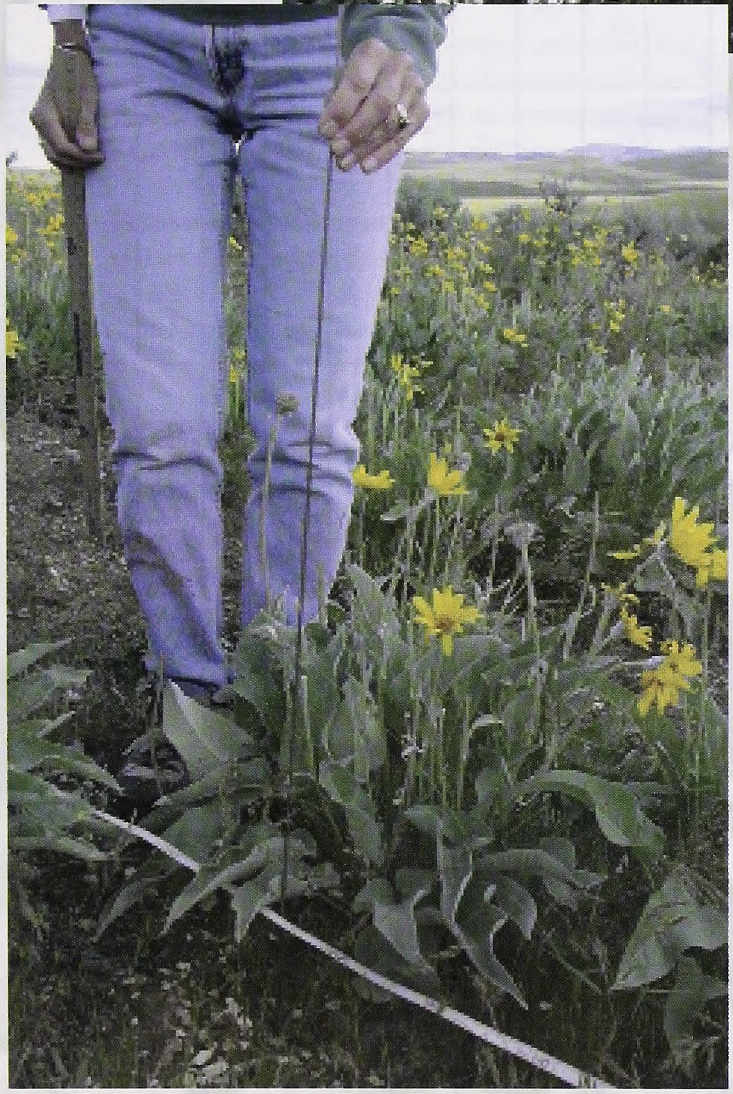
Description Year:	**Counties:**	**State:**
Evaluator(s):	**Agency:**	
Home Range Name:	**Population:**	
Lek Group Name:	**General Location:**	

Data Sources	
Land Cover Type Data Sources:	
Anthropogenic Features Data Sources:	
Population Data Sources:	
Data Storage Location:	
Software and Version:	
Mapping Grain:	**Home Range Area Extent (km^2):**

Habitat Indicator Descriptions	
1. Seasonal Habitat Availability	a. Area of occupied breeding habitat (km^2) =
	a. Area of occupied summer habitat (km^2) =
	a. Area of occupied winter habitat (km^2) =
	b. Area of potential breeding habitat (km^2) =
	b. Area of potential summer habitat (km^2) =
	b. Area of potential winter habitat (km^2) =
	c. Area of nonhabitat (km^2) (optional) =
	Discussion:
2. Seasonal Use Area Connectivity	Breeding to summer (km edge/km^2 of habitat) =
	Summer to winter (km edge/km^2 of habitat) =
	Winter to breeding (km edge/km^2 of habitat) =
3. Anthropogenic Disturbances	a. Densities of linear features (km/km^2) =
	b. Densities of point features (sites/km^2) =
	c. Area of nonhabitat or unsuitable habitat inclusions (km^2) =
	Discussion:

Fine-Scale (Third-Order) Suitability Summary	
✓	**Check the one description below that best describes the home range:**
	Suitable: Home ranges have connected seasonal use areas. Anthropogenic features that can disrupt seasonal movements or cause mortality are generally absent or at least not widespread.
	Marginal: Home ranges have poorly connected or disjunct seasonal use areas. Anthropogenic features that can disrupt seasonal movements or cause mortality may occur within the home range.
	Unsuitable: Home ranges have seasonal use areas with predominantly grassland, woodland, or incompatible land uses (anthropogenic features) not conducive to sage-grouse seasonal movements or habitat use. Most leks have been abandoned or have few remaining birds.
Discussion:	

Site-Scale (Fourth-Order) Data Forms



Form S-1: Sage-Grouse Site-Scale Seasonal Habitat Data Summary

Date:
County:
State:
Evaluator(s):
Population:
Home Range Name:
Seasonal Habitat:
Associated Leks:

Land Cover Type	Ecological Site	Area (ha/ac) or Length (km/mi)	Transects (#)	Indicator Values from Data Forms (means in most cases)								
				$\overline{x}$ Sage Cover (%)	$\overline{x}$ Sage Ht. (cm)	$\overline{x}$ Predominant Sage Shape (# of S and C)	$\overline{x}$ PG Ht. (cm)	$\overline{x}$ PF Ht. (cm)	$\overline{x}$ PG Cover (%)	$\overline{x}$ PF Cover (%)	Preferred Forb Species (#)	Lek Hbt. Avg. Distance to Sage Cover (m)

Form S-1: Sage-Grouse Site-Scale Seasonal Habitat Data Summary Directions

1. Use this form to summarize seasonal habitat field transect data collected using methods outlined in this document.

2. Complete all location information at the top of the form. Information should be consistent with information on the field data forms. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names are found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River home range).

   Seasonal Habitat: List the one season (breeding, summer, or winter) to which the data pertain. The same area may provide more than one seasonal habitat need, but data must be collected at the appropriate time of year for descriptions.

   Associated Leks: List the two largest occupied leks to which the breeding habitat is associated. Use identification numbers or names that are used in the statewide database.

3. Complete the data section of the form:

   Land Cover Type: Identify the land cover of the seasonal habitat being summarized.

      Upland communities: Use plant alliances or associations (Reid et al. 2002) for sagebrush or grassland communities; use www.natureserve.org/explorer (International Classification of Ecological Communities) or other sampling strata to describe the habitat (e.g., percent sagebrush categories). Use the species symbol for dominant species in the overstory and understory (table B-1), for example ARTRW8 (alliance level – Wyoming big sagebrush) or ARTRW8/FEID (association level – Wyoming big sagebrush/Idaho fescue).

      Riparian or wetland communities: Use site type (riparian areas, wet meadows, springs) or more detailed classification using Cowardin et al. (1979) or riparian type (regional classification systems) to which the data pertain.

   Ecological Site: Refer to soil maps, range site guides, and ecological site descriptions where available and record the appropriate ecological site. Use the species symbol for dominant species in the overstory and understory.

   Area or Length: Record the polygon area (indicating ha/ac) or linear length for riparian areas (indicating km/mi) of the habitat sampled (e.g., the land cover type).

   Transects: Record the number of 50-m transects or sites measured within the land cover type. If transect length was adjusted due to polygon size or shape, annotate as needed.

   Indicator Values: Record the mean or total numbers as indicated for each measurement (sagebrush cover, sagebrush height, sagebrush shape, perennial grass height, perennial forb height, perennial grass cover, perennial form cover, preferred forb species, and lek habitat distance to sage cover).

      Sagebrush Height: Sagebrush height above ground for most seasons and above snow for winter habitat.

      Predominant Sagebrush Shape: Estimate the number of spreading (S) or columnar (C) plants (see visual shape guide, figure 13).

Form S-2: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Breeding Habitat (Leks)

Date:	County:	State:	Evaluator(s):
Population:			Home Range Name:
Land Cover Type:			Lek ID#:
GPS file #:			Lek Status (circle one): Occupied Unoccupied Undetermined
UTM:			

Habitat Indicator Suitability Range						
Habitat Indicator	**Suitable**	✓	**Marginal**	✓	**Unsuitable**	✓
Availability of Sagebrush Cover	*Lek has adjacent protective sagebrush cover (within 100 m)*		*Sagebrush within 100 m provides very little protective cover*		*Adjacent sagebrush cover is >100 m*	
Proximity of Detrimental Land Uses	*Detrimental land uses are not within line of sight of lek and absent to uncommon within 3 km of lek*		*Detrimental land uses are within line of sight of lek and uncommon or few within 3 km of lek*		*Detrimental land uses are within the vicinity of the lek site*	
Proximity of Trees or Other Tall Structures	*Trees or other tall structures are not within line of sight of lek and none to uncommon within 3 km of lek*		*Trees or other tall structures are within line of sight of lek and uncommon or scattered within 3 km of lek*		*Trees or other tall structures are within the vicinity of the lek site*	
Site-Scale Suitability	**Suitable**		**Marginal**		**Unsuitable**	

Anthropogenic Noise Description:

Rationale for Overall Suitability Rating:

Form S-2: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Breeding Habitat (Leks) Directions

1. Complete one form for each occupied, unoccupied, or undetermined lek in the home range or lek group, as needed.

2. Complete all location information at the top of the form. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names are found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River home range).

   Land Cover Type: Identify the cover type at the lek site. Use plant alliances or associations (Reid et al. 2002) for sagebrush or grassland communities; use www.natureserve.org/explorer (International Classification of Ecological Communities) or other sampling strata to describe the habitat (e.g., percent sagebrush categories). Use the species symbol for dominant species in the overstory and understory (table B-1), for example ARTRW8 (alliance level – Wyoming big sagebrush) or ARTRW8/FEID (association level – Wyoming big sagebrush/Idaho fescue). Note whether the lek is located in a nonhabitat (e.g., agriculture, urban, industrial) area. If the lek is located on a road, in a livestock watering area, or on a similar type of surface within a plant community, indicate this cover type in the following manner: ARTRW8:road; ARTRW8:trough area.

   Lek ID #: Use the identification number or name that is used in the statewide database.

   Lek Status: Determine the status using the following definitions. Note that the specific terms and definitions for lek status may vary by state. Use the terminology appropriate for your area.

      Occupied lek: [*Greater Sage-Grouse*] A lek that has been active during at least one breeding season within the prior 5 years. [*Gunnison Sage-Grouse*] A lek that has been attended by males in the previous 5 years.

      Unoccupied lek: [*Greater Sage-Grouse*] A lek that has not been active during a period of 5 consecutive years. [*Gunnison Sage-Grouse*] A lek that has been inactive for 5 years.

      Undetermined lek: Any lek that has not been documented as active in the last 5 years, but for which survey information is insufficient to designate the lek as unoccupied.

3. Complete indicator measurements:

   Availability of Sagebrush Cover: Adjacent sagebrush distance is measured from the edge of the lekking area to the edge of the nearest stand of mature sagebrush of sufficient extent to provide protective cover.

   Proximity of Detrimental Land Uses: Such land uses include oil/gas wells, roads, agricultural fields, subdivisions, etc.

   Proximity of Trees or Other Tall Structures: Trees and tall structures are considered "within the vicinity" when they provide avian perch sites with a view of birds on the lek.

4. Determine the appropriate suitability category and mark (✔) each indicator as suitable, marginal, or unsuitable.

5. Describe **anthropogenic noise**. Indicate the presence of and describe any anthropogenic noises observed during the lekking period. Identify the noise source (highway vehicles, generator, wind turbines, military overflights, etc.) and describe the occurrence frequency (constant or periodic), volume (loud to soft), and pitch (high to low). Use a decibel meter, if available, to record data when anthropogenic noises are a concern for the lek.

6. Determine **site-scale suitability**. Overall suitability takes into consideration the relationship between the indicators and their relative importance. This evaluation is based on professional judgment using the indicators for guidance. Explain overall site suitability in the rationale section.

7. Attach photographs of the lek site.

8. Provide a copy of this form to the state wildlife agency's sage-grouse coordinator.

Form S-3: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Breeding Habitat (Nesting/Early Brood-Rearing)

Date:	County:	State:	Evaluator(s):
Population:		Home Range Name:	
Land Cover Type:		Ecological Site:	
Associated Leks:		Number of Transects:	
Area Sampled (ha/ac):		Site Info. (circle one): Arid Site Mesic Site	
List UTM Coordinates (coordinates, zone, datum) of All Transects:			

		Habitat Indicator Suitability Range					
Habitat Indicator	$\bar{x}$	**Suitable**	✓	**Marginal**	✓	**Unsuitable**	✓
Sagebrush Canopy Cover (mean)		15 to 25%		5 to <15% or >25%		<5%	
Sagebrush Height							
Mesic Site (mean)		40 to 80 cm		20 to <40 cm or >80		<20 cm	
Arid Site (mean)		30 to 80 cm		20 to <30 cm or >80		<20 cm	
Predominant Sagebrush Shape (mode)		Spreading		Mix of spreading and columnar		Columnar	
Spreading (*n*)							
Columnar (*n*)							
Perennial Grass Height (mean)		≥18 cm		10 to <18 cm		<10 cm	
Perennial Forb Height (mean)		≥18 cm		10 to <18 cm		<10 cm	
Perennial Grass Cover							
Mesic Site (mean)		≥15%		5 to <15%		<5%	
Arid Site (mean)		≥10%		5 to <10%		<5%	
Perennial Forb Cover							
Mesic Site (mean)		≥10%		5 to <10%		<5%	
Arid Site (mean)		≥5%		3 to <5%		<3%	
Preferred Forb Availability (relative to site potential)		Preferred forbs are common with several species present		Preferred forbs are common but only a few species are present		Preferred forbs are rare	
Number of Preferred Forb Species (*n*)							

Site-Scale Suitability Suitable		Marginal		Unsuitable	

Does ecological site potential limit suitability potential? (circle one) Yes No Unknown

Drought Condition (circle one): Extreme Drought Severe Drought Moderate Drought Mid-Range Moderately Moist Very Moist Extremely Moist

Rationale for Overall Suitability Rating:

Form S-3: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Breeding Habitat (Nesting/Early Brood-Rearing) Directions

1. Use this worksheet to interpret field data collected using methods (LPI/LIDF and forb diversity) outlined in this appendix and summarized on the "Sage-Grouse Site-Scale Seasonal Habitat Data Summary" (form S-1).

2. Complete all site location information at the top of the form. Be sure to list all UTM coordinates or other identifying feature of all sites being summarized. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names are found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River home range).

   Land Cover Type: Identify the cover type of the data collected. Use plant alliances or associations (Reid et al. 2002) for sagebrush or grassland communities; use www.natureserve.org/explorer (International Classification of Ecological Communities) or other sampling strata to describe the habitat (e.g., percent sagebrush categories). Use the species symbol for dominant species in the overstory and understory (table B-1), for example ARTRW8 (alliance level – Wyoming big sagebrush) or ARTRW8/FEID (association level – Wyoming big sagebrush/Idaho fescue).

   Ecological Site: Refer to soil maps, range site guides, and ecological site descriptions where available and record the appropriate ecological site. Use the species symbol for dominant species in the overstory and understory.

   Associated Leks: List the two largest occupied leks to which the breeding habitat is associated. Use identification numbers or names that are used in the statewide database.

   Number of Transects: Record the number of 50-m transects completed within the land cover type.

   Area Sampled: Record the total area (indicating ha/ac) of the land cover type sampled.

   Site Info.:

      Arid Site: Applies to sagebrush ecological sites generally in the 25-30 cm (10-12 in) precipitation zone. Wyoming big sagebrush is a common big sagebrush subspecies for this type of site.

      Mesic Site: Applies to sagebrush ecological sites generally in a >30 cm (12 in) precipitation zone. Mountain big sagebrush is a common big sagebrush subspecies for this type of site.

3. Transfer data from the "Sage-Grouse Site-Scale Seasonal Habitat Data Summary" (form S-1) to this form. Enter the appropriate mean ($\overline{x}$) and number (n) values for the indicators in the column under $\overline{x}$.

   Predominant Sagebrush Shape: Estimate the number of spreading (S) or columnar (C) plants (see visual shape guide, figure 13).

   Perennial Forb Height (Optional): In many situations, perennial forb heights can be quite variable or provide minimal contribution to herbaceous structure. Therefore, in most cases, use perennial grass heights for the suitability rating.

   Preferred Forb Availability: Check the appropriate suitability category based on data derived using the "Sage-Grouse Forb Diversity Data Form." The suitability evaluation must be relative to ecological site potential.

4. Determine the appropriate suitability category and mark (✔) each indicator as suitable, marginal, or unsuitable.

5. Determine **site-scale suitability**. Overall suitability takes into consideration the relationship between the indicators and their relative importance. This evaluation is based on professional judgment using the indicators for guidance. Explain overall site suitability in the rationale section.

6. Indicate if **site potential** is a factor for a suitability description of marginal or unsuitable. Explain further in the rationale section.

7. Indicate **drought condition** using local weather station data or as reported for the region of concern on the National Weather Service website: www.ncdc.noaa.gov/oa/climate/research/us-drought-monthly.html.

8. Attach field data sheet(s) and photographs used for this site-scale description.

9. Provide a copy of this form to the state wildlife agency's sage-grouse coordinator.

Form S-4: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Upland Summer/Late Brood-Rearing Habitat

Date: | County: | State: | Evaluator(s):

Population: | Home Range Name:

Land Cover Type: | Ecological Site:

Number of Transects: | Area Sampled (ha/ac):

List UTM Coordinates (coordinates, zone, datum) of All Transects:

Habitat Indicator Suitability Range

Habitat Indicator	$\bar{x}$	Suitable	✔	Marginal	✔	Unsuitable	✔
Sagebrush Cover (mean)		10 to 25%		5 to <10% or >25%		<5%	
Sagebrush Height (mean)		40 to 80 cm		20 to <40 or >80 cm		<20cm	
Perennial Grass and Forb Cover (mean)		≥15 %		5 to <15%		<5%	
Preferred Forb Availability (relative to site potential)		Preferred forbs are common with appropriate numbers of species present		Forbs are common but only a few preferred species are present		Preferred forbs are rare	
Number of Preferred Forb Species (*n*)							

Site-Scale Suitability	Suitable		Marginal		Unsuitable	

Does site potential limit suitability? (circle one) Yes No Unknown

Drought Condition (circle one): Extreme Drought Severe Drought Moderate Drought Mid-Range Moderately Moist Very Moist Extremely Moist

Rationale for Overall Suitability Rating:

Form S-4: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Upland Summer/Late Brood-Rearing Habitat Directions

1. Use this worksheet to interpret field data summarized on the "Sage-Grouse Site-Scale Seasonal Habitat Data Summary" (form S-1).

2. Complete all location information at the top of the form. Be sure to list all UTM coordinates or other identifying feature of all sites being summarized. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names are found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River home range).

   Land Cover Type: Identify the cover type of the data collected. Use plant alliances or associations (Reid et al. 2002) for sagebrush or grassland communities; use www.natureserve.org/explorer (International Classification of Ecological Communities) or other sampling strata to describe the habitat (e.g., percent sagebrush categories). Use the species symbol for dominant species in the overstory and understory (table B-1), for example ARTRW8 (alliance level – Wyoming big sagebrush) or ARTRW8/FEID (association level – Wyoming big sagebrush/Idaho fescue).

   Ecological Site: Refer to soil maps, range site guides, and ecological site descriptions where available and record the appropriate ecological site. Use the species symbol for dominant species in the overstory and understory.

   Number of Transects: Record the number of 50-m transects completed within the land cover type.

   Area Sampled: Record the total area (indicating ha/ac) of the land cover type sampled.

3. Transfer data from the "Sage-Grouse Site-Scale Seasonal Habitat Data Summary" (form S-1) to this form. Enter the appropriate mean ($\overline{x}$) and number (n) values where appropriate for the indicators in the column under $\overline{x}$.

   Preferred Forb Availability: Check the appropriate suitability category based on data derived using the "Sage-Grouse Preferred Forb Diversity Form." The suitability evaluation must be relative to abundance, diversity, and availability relative to ecological site potential. Write a short narrative in the notes section, based on the species observed and available site information.

4. Determine the appropriate suitability category and mark (✔) each indicator as suitable, marginal, or unsuitable.

5. Determine **site-scale suitability**. Overall suitability takes into consideration the relationship between the indicators and their relative importance. This evaluation is based on professional judgment using the indicators for guidance. Explain overall site suitability in the rationale section.

6. Indicate if **site potential** is a factor for a suitability description of marginal or unsuitable. Explain further in the rationale section.

7. Indicate **drought condition** using local weather station data or as reported for the region of concern on the National Weather Service website: www.ncdc.noaa.gov/oa/climate/research/us-drought-monthly.html.

8. Attach field data sheet(s) and photographs used for this site-scale description.

9. Provide a copy of this form to the state wildlife agency's sage-grouse coordinator.

Form S-5: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Riparian Summer/Late Brood-Rearing Habitat

Date:	County:	State:	Evaluator(s):

Population:

Home Range Name:

Land Cover Type:

Site Type (circle one): Riparian Areas Wetland/Wet Meadows Springs Lakebeds All Other

Number of Transects:

Area (ha/ac) or Distance (km/mi) Sampled:

List UTM Coordinates (coordinates, zone, datum) of All Transects:

Habitat Indicator Suitability Range

Habitat Indicator	$\bar{x}$ or n	Suitable	✓	Marginal	✓	Unsuitable	✓
Riparian Stability	▨	Majority of areas are in PFC		Majority of areas are FAR		Majority of areas are NF	
PFC (*n*)							
FAR (*n*)							
NF (*n*)							
Preferred Forb Availability (relative to site potential)	▨	Preferred forbs are common with appropriate numbers of species present		Preferred forbs are common but only a few species are present		Preferred forbs are rare	
Number of Preferred Forb Species (*n*)							
Availability of Sagebrush Cover (mean)		Sagebrush cover is adjacent to brood-rearing areas (<100 m)		Sagebrush cover is in close proximity to brood-rearing areas (100 to 275 m)		Sagebrush cover is unavailable (>275 m)	

Site-Scale Suitability	Suitable		Marginal		Unsuitable	

Drought Condition (circle one): Extreme Drought Severe Drought Moderate Drought Mid-Range Moderately Moist Very Moist Extremely Moist

Rationale for Overall Suitability Rating:

Form S-5: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Riparian Summer/Late Brood-Rearing Habitat Directions

1. Use this worksheet to interpret field data collected using the forb diversity method outlined in this appendix and summarized on the "Sage-Grouse Site-Scale Seasonal Habitat Data Summary" (form S-1).

2. Complete all location information at the top of the form. Be sure to list all UTM coordinates or other identifying feature of all sites being summarized. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names are found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River home range).

   Land Cover Type (Optional): Identify the wetland (Cowardin et al. 1979) or riparian type (regional classification systems) of the habitat sampled. This data may be important to record when more detailed descriptions of summer habitats are desired (i.e., with sites stratified by cover type).

   Site Type: Identify the type of habitat sites sampled.

   Number of Transects: Record the number of 50-m transects or sites measured within the land cover type.

   Area or Distance Sampled: Record the total area (indicating ha/ac) or distance for riparian areas (indicating km/mi) of the site type or land cover type sampled.

3. Transfer data from the "Sage-Grouse Site-Scale Seasonal Habitat Data Summary" (form S-1) to this form. Enter the appropriate mean ($\overline{x}$) and number (n) values and PFC data where appropriate for the indicators in the column under $\overline{x}$.

   Riparian Stability: Record the number of sampling sites that were in proper functioning condition (PFC), functional–at risk (FAR), or nonfunctional (NF) (Prichard et al. 1998, 2003). Current PFC data can be used, if available. If PFC data cannot be obtained from other sources or collected directly, then the other two indicators should be used to assess habitat suitability. Include lotic and lentic riparian habitats.

   Preferred Forb Availability: Check the appropriate suitability category based on data derived using the "Sage-Grouse Forb Diversity Data Form." The suitability evaluation must be relative to abundance, diversity, and availability relative to ecological site potential.

   Availability of Sagebrush Cover: Distance is measured from the edge of the riparian area to the edge of the nearest stand of mature sagebrush of sufficient extent to provide protective cover.

4. Determine the appropriate suitability category and mark (✓) each indicator as suitable, marginal, or unsuitable.

5. Determine **site-scale suitability**. Overall suitability takes into consideration the relationship between the indicators and their relative importance. This evaluation is based on professional judgment using the indicators for guidance. Explain overall site suitability in the rationale section.

6. Indicate **drought condition** using local weather station data or as reported for the region of concern on the National Weather Service website: www.ncdc.noaa.gov/oa/climate/research/us-drought-monthly.html.

7. Attach field data sheet(s) and photographs used for this site-scale description.

8. Provide a copy of this form to the state wildlife agency's coordinator for sage-grouse conservation.

Form S-6: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Winter Habitat

Date:

County:

State:

Evaluator(s):

Population:

Home Range Name:

Land Cover Type:

Ecological Site:

Number of Transects:

Area Sampled (ha/ac):

List UTM Coordinates (coordinates, zone, datum) of All Transects:

		Habitat Indicator Suitability Range					
Habitat Indicator	$\bar{x}$	**Suitable**	✓	**Marginal**	✓	**Unsuitable**	✓
Sagebrush Cover (mean)		≥10 %		5 to <10%		<5%	
Sagebrush Height (above snow) (mean)		≥25 cm		>10 to <25 cm		≤10 cm	

Site-Scale Suitability	**Suitable**		**Marginal**		**Unsuitable**	

Rationale for Overall Suitability Rating:

Form S-6: Sage-Grouse Site-Scale Habitat Suitability Worksheet – Winter Habitat Directions

1. Use this worksheet to interpret field data summarized on the "Sage-Grouse Site-Scale Seasonal Habitat Data Summary" (form S-1).

2. Complete all location information at the top of the form. Be sure to list all UTM coordinates or other identifying feature of all sites being summarized. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names are found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River home range).

   Land Cover Type: Identify the cover type of the data collected. Use plant alliances or associations (Reid et al. 2002) for sagebrush or grassland communities; use www.natureserve.org/explorer (International Classification of Ecological Communities) or other sampling strata to describe the habitat (e.g., percent sagebrush categories). Use the species symbol for dominant species in the overstory and understory (table B-1), for example ARTRW8 (alliance level – Wyoming big sagebrush) or ARTRW8/FEID (association level – Wyoming big sagebrush/Idaho fescue).

   Ecological Site: Refer to soil maps, range site guides, and ecological site descriptions where available and record the appropriate ecological site. Use the species symbol for dominant species in the overstory and understory.

   Number of Transects: Record the number of 50-m transects completed within the land cover type.

   Area Sampled: Record the total area (indicating ha/ac) of the land cover type within the administrative area assessed (e.g., pasture, allotment).

3. Transfer data from the "Sage-Grouse Site-Scale Seasonal Habitat Data Summary" (form S-1) to this form. Enter the mean ($\bar{x}$) for the indicators in the column under $\bar{x}$.

4. Determine the appropriate suitability category and mark (✔) each indicator as suitable, marginal, or unsuitable.

5. Determine **site-scale suitability**. Overall suitability takes into consideration the relationship between the indicators and their relative importance. This evaluation is based on professional judgment using the indicators for guidance. Explain overall site suitability in the rationale section.

6. Attach field data sheet(s) and photographs used for this site-scale description.

7. Provide a copy of this form to the state wildlife agency's sage-grouse coordinator.

Form S-7: Sage-Grouse Site-Scale Seasonal Habitat Site Suitability Summary

Date:	County:	State:	Evaluator(s):
Population:			Home Range Name:
Associated Leks:			

Seasonal Habitat Information						Suitability		
						Current	Future	
Seasonal Habitat	Land Cover Type	Ecological Site	Area (ha/ac) *(upland)*	Length (km/mi) *(riparian)*	Number of Sites *(leks, wet meadows, springs, etc.)*	Suitable, Marginal, Unsuitable	Site potential limiting?	Habitat components present?

Form S-7: Sage-Grouse Site-Scale Seasonal Habitat Site Suitability Summary Directions

1. Use this form to summarize site-scale seasonal habitat suitability descriptions (forms S-2 through S-6) for land cover types within a home range area.

2. Complete all location information at the top of the form. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names are found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River home range).

   Associated Leks: List the two largest occupied leks to which the breeding habitat is associated. Use identification numbers or names that are used in the statewide database.

3. Transfer data from the seasonal habitat suitability worksheets (forms S-2 through S-6) to this form.

   Seasonal Habitat: List one of the following: lek, nesting/early brood-rearing, summer/late brood-rearing, or winter, for each seasonal habitat summarized.

   Land Cover Type: Identify the land cover type of the seasonal habitat.

      Upland communities: Use plant alliances or associations (Reid et al. 2002) for sagebrush or grassland communities; use www.natureserve.org/explorer (International Classification of Ecological Communities) or other sampling strata to describe the habitat (e.g., percent sagebrush categories). Use the species symbol for dominant species in the overstory and understory (table B-1), for example ARTRW8 (alliance level – Wyoming big sagebrush) or ARTRW8/FEID (association level – Wyoming big sagebrush/Idaho fescue).

      Riparian or wetland communities: Use site type (riparian areas, wet meadows, springs) or more detailed classification using Cowardin et al. (1979) or riparian type (regional classification systems) to which the data pertain.

   Ecological Site: Refer to soil maps, range site guides, and ecological site descriptions where available and record the appropriate ecological site. Use the species symbol for dominant species in the overstory and understory.

   Area/Length/Number of Sites: Record the area for upland habitat (indicating ha/ac), linear length for riparian habitat (indicating km/mi), or number of sites (leks, wet meadows, springs, etc.) sampled.

   Current Suitability: Record the overall site-scale suitability as suitable (S), marginal (M), or unsuitable (U).

   Future Suitability: Record any site-scale ecological constraints for the cover type to provide habitat in the future. This information applies only to those sites that are currently providing marginal or unsuitable site-scale conditions.

      Site potential limiting?: If ecological site potential indicates that the site may provide suitable habitat in the future, record "No." If ecological site potential is limiting suitability, record "Yes."

      Habitat components present?: If there is sagebrush recruitment and forbs and perennial grasses are present in suitable amounts, record "Yes." If recruitment of these life forms is lacking, record "No."

Plot Metadata Form

Site:	Ownership:	Establishment Date:
Plot ID:		Visit Date:

Evaluator(s):

GPS Coordinate System:	Datum :	Zone (if applicable):	Elevation: ☐m ☐ft

Transect	Azimuth	Length ☐m ☐ft		Latitude/Northing	Longitude/Easting	Slope (%)
			Start			
			Start			Aspect (°)
			Start			

Directions to the Plot:

Population:	Home Range Name:
Land Cover Type:	Ecological Site:
Associated Leks:	Area (ha/ac) or Distance (km/mi) Sampled:
Site Info.: ☐ Arid Site ☐ Mesic Site	Seasonal Habitat:

PFC Status (riparian areas only): ☐ PFC ☐ FAR ☐ NF ☐ Unknown

Comments:

Plot Photos:

Photo	Description

Plot Metadata Directions

1. Complete all location information at the top of the sheet. Be sure to list UTM coordinates and other identifying features of the site. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names are found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River Home Range).

   Land Cover Type: Identify the land cover type of the data. Use plant alliances or associations (Reid et al. 2002) for sagebrush or grassland communities; www.natureserve.org/explorer (International Classification of Ecological Communities) or other sampling strata used to describe the habitat (e.g., % sagebrush categories). Use the species symbol (table B-1) for dominant species in the overstory and understory (Examples: ARTRW8 (alliance level – Wyoming big sagebrush) or ARTRW8/FEID (association level – Wyoming big sagebrush/Idaho fescue).

   Ecological Site: Refer to soil maps and range site guides, and ecological site descriptions where available and record the appropriate ecological site. Use the species symbol for dominant species in the overstory and understory.

   Associated Leks: List the two largest occupied leks to which the breeding habitat is associated. Use identification numbers or names that are used in the statewide database.

   Area or Distance Sampled: Record the total area (indicating ha/ac) or distance for riparian areas (indicating km/mi) of the site type or land cover type sampled.

   Site Info.:

      Arid Site: Applies to sagebrush ecological sites generally in the 25-30 cm (10-12 in) precipitation zone. Wyoming big sagebrush is a common big sagebrush subspecies for this type of site.

      Mesic Site: Applies to sagebrush ecological sites generally in a >30 cm (12 in) precipitation zone. Mountain big sagebrush is a common big sagebrush subspecies for this type of site.

   Seasonal Habitat: List one or more of the following, as appropriate: lek, nesting/early brood-rearing, summer/late brood-rearing, or winter.

2. Take photographs of the study site. At least one photograph must be taken at each transect/evaluation area. Photos will prove invaluable in locating evaluation areas in subsequent years. They will also be of substantial utility in the office when preparing evaluation documents and documenting habitat condition.

   a. Complete a photo card showing, at a minimum, the date, location, allotment, and transect number.
   b. With the photo card near the zero end of the tape, take a general photo of the area, sighting down the tape from eye level, showing landmarks in the background, if possible. A cover board or meter stick should be in the picture for a frame of reference.
   c. In a representative location along or near the tape, place the photo card near the base of a sagebrush plant, and take a tangential closeup photo from near ground level (2-3 ft) toward the shrub/ground interface, to document herbaceous conditions and cover. A cover board or meter stick should be in the picture for a frame of reference.
   d. Optional: Take one or more other closeups or panoramic photos as needed. A photo showing sagebrush canopy cover percent may also be desirable, following completion of the line intercept.

Line-Point Intercept Data Form

Page of
Date:
Plot ID:
Transect:
Evaluator(s):
Azimuth:
Intercept (Point) Spacing: ☐cm ☐in
Height: ☐cm ☐in

Pt.	Top Layer	Lower Layers			Soil Surface	Pt.	Top Layer	Lower Layers			Soil Surface
		Code 1	Code 2	Code 3				Code 1	Code 2	Code 3	
1						26					
2						27					
3						28					
4						29					
5						30					
6						31					
7						32					
8						33					
9						34					
10						35					
11						36					
12						37					
13						38					
14						39					
15						40					
16						41					
17						42					
18						43					
19						44					
20						45					
21						46					
22						47					
23						48					
24						49					
25						50					

% foliar cover = _____ top layer pts (1st col) x 2 = _____%

% bare ground = _____ pts (w/NONE over S) x 2 = _____%

Top layer codes: Species code, common name, or NONE (no cover).

Lower layers codes: Species code, common name, L (herbaceous litter), WL (woody litter, >5 mm (~1/4 in) diameter), VL (vagrant lichen).

Unknown Species Codes:

AF# = annual forb
PF# = perennial forb
AG# = annual grass
PG# = perennial grass
SH# = shrub
TR# = tree

Soil Surface (do not use litter):

G = gravel (≤5 mm or ~1/4 in)
R = rock (>5 mm or ~1/4 in)
BR = bedrock
EL = embedded litter
D = duff
M = moss
LC = visible lichen crust on soil
S = soil

Line-Point Intercept Directions

Note: The HAF site-scale protocol for line-point intercept is the same as the BLM's core method. Directions for the method are given below, but readers can refer to Herrick et al. (2005) (or the most current version) for more detail.

Equipment:

Tape, 50 m	Stakes for tape (at least two spikes; old, medium to large screwdrivers work well)
Pin flag or pointer or other point intercept device: straight piece of wire or rod at least 1 m long and less than 2.5 mm in diameter	Meter stick (for measuring shrub and grass/forb heights)
Digital camera (5 megapixel minimum), extra camera battery	Photo cards and markers or small dry-erase board and marker
Topographic map and aerial photographs with project area, general cover types, and pasture boundaries delineated	GPS unit, compass
Forms and/or electronic data entry device with extra battery, pencils	Ecological Site Guides
Calculator	

Protocol:

1. Complete all metadata information at the top of the LPI field form for each transect, making sure that the plot identification information (i.e., plot number) matches that recorded on the overall plot metadata form. If more than 50 points are being recorded on a transect, attach additional forms as needed.

2. Pull out the tape and anchor each end with a steel pin. Keep measuring tape taught and straight. Keep measuring tape as close to the ground as possible (thread under shrubs using a steel pin as a needle), but not so close that it disturbs the soil surface or affects the natural way the vegetation stands below the tape (figures B-1 and B-2).

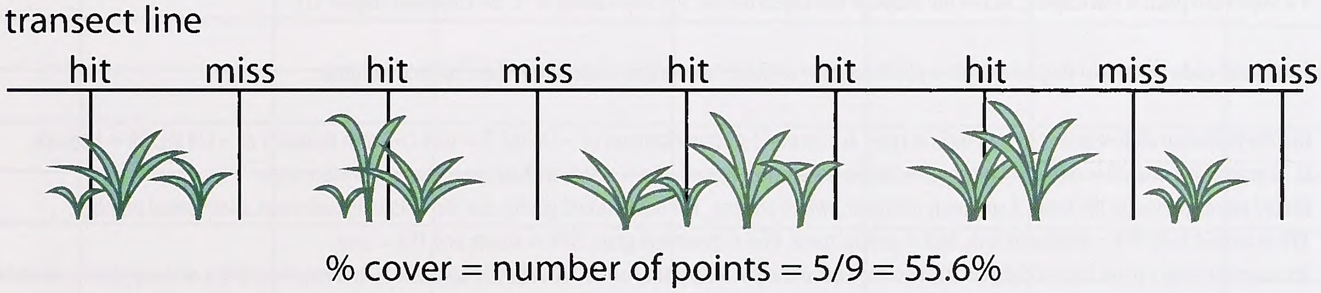


Figure B-1. The line-point intercept method can be used to measure foliar cover and vegetation height of all grass, forb, and shrub species at a site or foliar cover of a single life form (e.g., sagebrush cover for winter habitat areas).

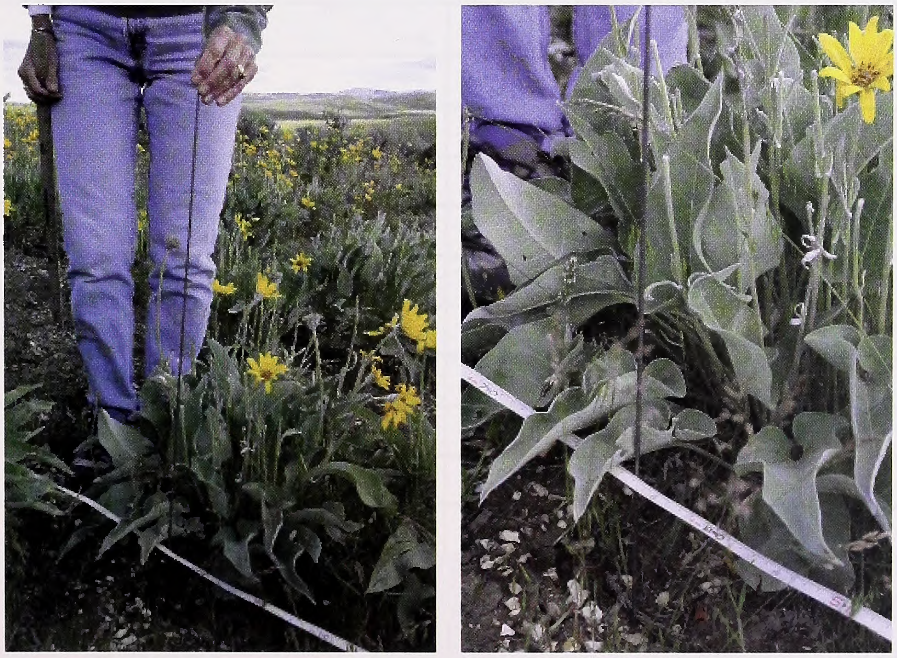


Figure B-2. Measuring plant species using the line-point intercept technique (pin size exaggerated to emphasize method).

3. Begin at the "0" end of the tape.

4. Working from left to right, record cover at each 1 m mark (or ½ m and 1 m mark for 100 points per transect). Begin recording at the first ½ m or 1 m mark depending on the number of points desired. Always stand on the same side of the line. Drop a pin flag to the ground from a standard height next to the tape. Keep the pin vertical. Make a "controlled drop" of the pin from the same height each time. Position the pin so its lower end is several centimeters above the vegetation, release it and allow it to slip through the hand until it hits the ground. A low drop height minimizes "bounces" off of vegetation but increase the possibility for bias. Do not guide the pin all the way to the ground. It is more important for the pin to fall freely to the ground than to fall precisely on the mark.

5. A laser with a bubble level can be used instead of the pin. This tool is useful in savannas where plant layers may be above eye level.

6. Once the pin flag is flush with the ground, record every plant species it intercepts:

   a. Record the species of the uppermost or first stem, leaf, or plant base intercepted in the "Top Layer" column using the USDA PLANTS database species code (http://plants.usda.gov), a four- to six-letter code based on the first two letters of the genus and species, subspecies, or the common name. If no leaf, stem, or plant base is intercepted, record "NONE" in the "Top Layer" column. Woody sagebrush plants should be identified to the subspecies.
   b. Record all additional species intercepted by the pin in the order that they are intercepted from top to bottom.
   c. Record all foliage whether alive or dead, but denote dead vegetation by using the appropriate checkbox in an electronic data collection database or circling the species on the data form. If both alive and dead canopy for a species is hit on the same point, record the live canopy. Sagebrush indicators for sage-grouse habitat are calculated from only live canopy hits and do not include dead stems of shrubs. Residual plant cover can be very important for sage-grouse nesting, so it is also important to denote live versus standing dead herbaceous vegetation on the field form. See Connelly et al. (2003), Monitoring of Greater Sage-grouse Habitats and Populations; http://sagemap.wr.usgs.gov/docs/grouse_habitat_book.pdf; and http://www.cnr.uidaho.edu/range357/notes/cover.pdf) for discussions on cover.
   d. Record each plant species only once, the first time it is intercepted, even if it is intercepted several times.
   e. Record the following codes for lower layers: "L" for herbaceous litter, if present (litter is defined as detached stems, roots, and leaves); "WL" for detached woody litter > 5 mm (~1/4 in) in diameter; or "VL" for vagrant lichen.
   f. If a sagebrush plant is intercepted, record the shape of the sagebrush as "S" for spreading or "C" for columnar (figure 13).

7. Record a species code (if the pin flag intercepts a plant base) or another soil surface code in the "Soil Surface" column.

   a. Use the following abbreviations for soil surface type: G = gravel (≤5 mm diameter or ~1/4 in), R = rock (>5 mm diameter or ~1/4 in), BR = bedrock, EL = embedded litter, D = duff, M = moss, LC = visible lichen crust on soil, and S = soil, without any other soil surface code.
   b. Record plant species (or life form, if species is unknown) when present. For unidentified plants, use the following codes and a sequential number: AF# = annual forb, PF# = perennial forb, AG# = annual grass, PG# = perennial grass, SH# = shrub, and TR# = tree.
   c. An intercept with a plant base is defined as when the end of the pin rests either on or immediately adjacent to and touching living or dead plant material that is rooted in the soil.
   d. Record embedded litter (EL) only where removal of the litter would leave an indentation in the soil surface or would disturb the soil surface, breaking the soil crust. Record duff (D) when there is no clear boundary between litter and mineral soil and litter is not removed during typical storms (occurring annually).
   e. Record lichen (LC) only if it is growing on soil, but not if it is attached to rock substrate. If mosses and lichens are recorded to species, write the species code in the "Soil Surface" column.

Vegetation Height/Sagebrush Shape Data Form

Page of | Date: | Plot ID: | Transect:

Evaluator(s):

Azimuth: | Intercept (Point) Spacing: ☐cm ☐in | Height: ☐cm ☐in

Point	Species	Woody Height	Sagebrush Shape	Species	Grass Height	Species	Forb Height

Average sagebrush height =

Average grass height =

Average forb height =

Vegetation Height/Sagebrush Shape Directions

Note: The HAF site-scale protocol for vegetation height is similar to the BLM's core method, but there are important differences between the two methods. Data collected using the HAF method can be used to supplement the BLM's core method for assessing the site-scale height indicators of sage-grouse habitat.

Protocol:

1. Record the species of woody and herbaceous plants for which the heights will be recorded.
2. Measure plants heights at the ½ m or 1 m intervals per transect. Do not record the height of the same plant twice.
3. Record the height of plants 0-2 m to the nearest centimeter and plants >2 m to the nearest 30 cm (~12 in).
4. For shrubs, record the maximum height in cm/in of the live portion of the shrub that is touched by the pin, excluding flower or seed stalks.
5. Record the shape of sagebrush only: S = spreading or C = columnar.
6. For perennial grasses and forbs, record the droop height (i.e., the highest point measured with no straightening by the observer or maximum natural height, figure B-3) of the tallest perennial grass or forb plant that is touched by the pin.
7. Woody or herbaceous litter are not measured.

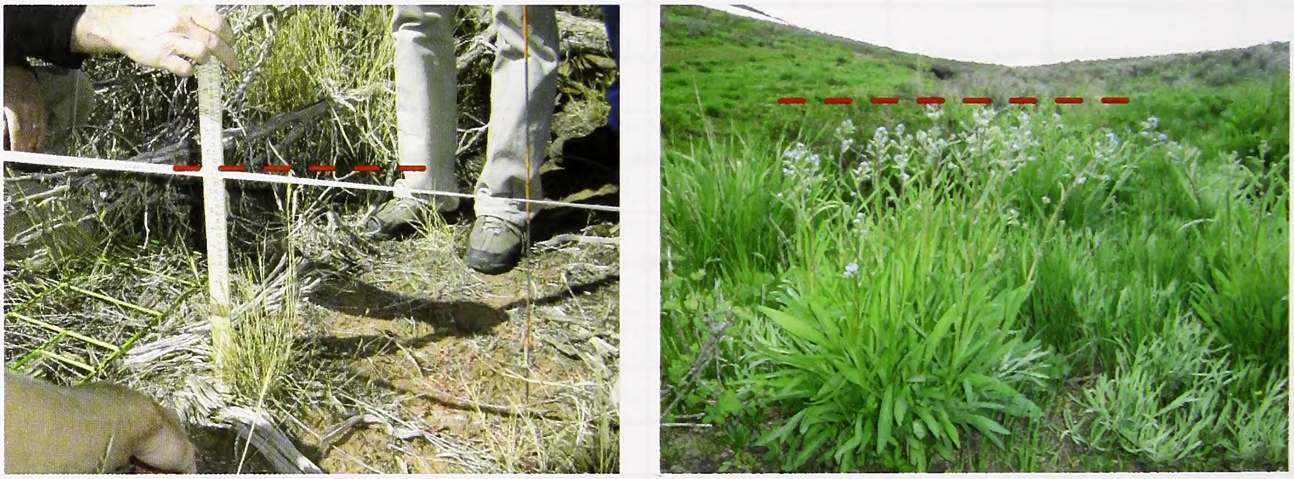


Figure B-3. Grass and forb height measurements. Record natural or "droop" height of grasses and forbs. Note the dashed red reference line.

Line-Point Intercept Data Summary

Page of	Plot:	Transect:
Evaluator(s):		
Shrubs	**Forbs**	**Grasses**
Sagebrush Cover *# Hits* ______________ % _____	Perennial Forb Cover *# Hits* ______________ % _____	Perennial Grass Cover *# Hits* ______________ % _____
Other Shrub Cover *# Hits* ______________ % _____	Annual Forb Cover *# Hits* ______________ % _____	Annual Grass Cover *# Hits* ______________ % _____
Sagebrush Shape (n) *S* __________ *C* ____________	Total Forb Cover *# AF+PF Hits* __________ % _____	Total Grass Cover *# AG+PF Hits* __________ % _____
Avg. Sagebrush Height (cm/in)	Avg. PF Height (cm/in)	Avg. PG Height (cm/in)
Comments:		

Sage-Grouse Habitat Indicator Calculations – Line-Point Intercept Data Summary Directions

Once the data has been collected, calculate the sage-grouse habitat indicators as described below. If using a tablet, computer, or other electronic data collection device, these indicators may be calculated automatically. If not, summarize the data and write the indicator calculations at the top of your field forms.

Cover of shrubs, forbs, and grasses:

- *Sagebrush Cover: Hits* = # of sagebrush hits, *% cover* = # points where a sagebrush was hit divided by the total number of transect points. Multiply the result by 100.
- *Other Shrub Cover: Hits* = # of total shrub hits, excluding sagebrush, *% cover* = # of points where a shrub was hit divided by the total number of transect points. Multiply the result by 100.
- *Perennial Forb Cover: PF Hits* = # of perennial forb hits, *% cover* = # of hits divided by total number of transect points. Multiply the result by 100.
- *Annual Forb Cover: AF Hits* = # of annual forb hits, *% cover* = # of hits divided by total number of transect points. Multiply the result by 100.
- *Total Forb Cover: PF+AF Hits* = # of perennial and annual forb hits, *% cover* = # total forb hits divided by total number of transect points. Multiply the result by 100.
- *Perennial Grass Cover: PG Hits* = # of perennial grass hits, *% cover* = # of hits divided by total number of transect points. Multiply the result by 100.
- *Annual Grass Cover: AG Hits* = # of annual grass hits, *% cover* = # of hits divided by total number of transect points. Multiply the result by 100.
- *Total Grass Cover: AG+PG Hits* = # of annual and perennial grass hits, *% cover* = # total grass hits divided by total number of transect points. Multiply the result by 100.

Height of shrubs, forbs, and grasses:

- *Avg. Sagebrush Height* = sum of all sagebrush recorded heights divided by total number of sagebrush plants measured.
- *Avg. Perennial Forb (PF) Height* = sum of all perennial forb recorded heights divided by total number of perennial forbs measured.
- *Avg. Perennial Grass (PG) Height* = sum of all perennial grass recorded heights divided by total number of perennial grass plants measured.
- *Note:* Relative to perennial forbs, it is recommended the suitability rating should focus on the cover estimates and preferred forb availability ratings rather than on height due to the variability in heights that can be encountered between forbs and grasses. However, average perennial forb height and/or average perennial forb and grass height (combined) can be calculated, if desired, to provide additional context to the description of the assessment area.
- *Sandberg bluegrass (or similar species):*

    1. Summarize cover and height for perennial grasses, excluding Sandberg bluegrass or similar short-statured perennial grasses.
    2. Summarize cover and height for Sandberg bluegrass.
    3. Summarize cover and height inclusive of all perennial grasses.

    Because shorter-statured perennial grasses such as Sandberg bluegrass may influence cover and height averages especially where abundant, the authors recommend that perennial grass metrics be summarized using all three methods, to provide additional context for the perennial grass suitability rating. For example, if cover, and height for perennial grasses, excluding Sandberg bluegrass (#1), are within the range of the suitable category in the HAF, then consider a ranking of "suitable" for the perennial grass indicator. However, if average cover (regardless of height) of these perennial grasses is not within the suitable category, use the cover and height averages for all perennial grasses, including Sandberg bluegrass (#3). Then, use the cover and height averages for the non-Sandberg perennial grasses (#1), as well as for Sandberg bluegrass itself (#2), to inform the rationale for the rating of the perennial grass indicator. Also, consider the capability of the site to provide species composition, cover, and structure for productive sage-grouse habitat on an annual basis.

Sagebrush shape:

- *Sagebrush Shape* = total # of sagebrush plants of each shape, spreading (S) or columnar (C), divided by total number of sagebrush plants measured.

Line Intercept and Daubenmire Frames Data Form (Electronic Version)

Date:	County:	State:	Evaluator(s):
Population:			Home Range Name:
Land Cover Type:			Associated Leks:
Ecological Site:			Seasonal Habitat:
Transect #:			Site Info. (circle one): Arid Site Mesic Site
UTM (coordinates, zone, datum):			

Transect Data Summary (see directions)

Shrubs	Forbs	Grasses
Sagebrush Cover (line intercept) % ______________	Perennial Forb Cover % ______________	Perennial Grass Cover % ______________
Avg. Sagebrush Height (cm)	Annual Forb Cover % ______________	Annual Grass Cover % ______________
Sagebrush Shape (n) Spreading :_________ Columnar:__________		
Other Shrub Cover % ______________	Total Forb Cover % ______________	Total Grass Cover % ______________
	Avg. PF Height (cm):	Avg. PG Height (cm):

Line Intercept Shrub Cover

Shrub Species	Intercept Start	Intercept End	Total Length	% Cover by Species

Line Intercept and Daubenmire Frames Data Form (Paper Version)

Date:	County:	State:	Evaluator(s):
Population:			Home Range Name:
Land Cover Type:			Associated Leks:
Ecological Site:			Seasonal Habitat:
Transect #:			Site Info. (circle one): Arid Site Mesic Site
Area Sampled (ha/ac):			UTM (coordinates, zone, datum):

Transect Data Summary (see directions)

Shrubs	Forbs	Grasses
Sagebrush Cover (line intercept) % ________	Perennial Forb Cover % ________	Perennial Grass Cover % ________
Avg. Sagebrush Height (cm)	Annual Forb Cover % ________	Annual Grass Cover % ________
Sagebrush Shape (n) Spreading: ________ Columnar: ________		
Other Shrub Cover % ________	Total Forb Cover % ________	Total Grass Cover % ________
	Avg. PF Height (cm):	Avg. PG Height (cm):

Species Name	Shrub Species							Notes
								Totals
Totals								
% Cover								

Daubenmire Cover Class and Vegetation Height Data Form (recorded at 2-m intervals)

Date:

County:

State:

Evaluator(s):

Transect #:

UTM (coordinates, zone, datum):

	Daubenmire Frame Number																									
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Notes
Ground Cover 1																										
Ground Cover 2																										
Ground Cover 3																										
Ground Cover 4																										
PF Ht																										
PG Ht																										
Other Shrub Ht																										
ARTR Ht																										
ARTR Shape																										

*Cover Class 1=0-5%, 2=>5-25%, 3=>25-50%, 4=>50-75%, 5=>75-95%, 6=>95-100%

Line Intercept and Daubenmire Frame Method Directions

Equipment:

Tape, 50 m	Stakes for tape (at least two spikes; old, medium to large screwdrivers work well)
Daubenmire frame 20 x 50 cm	Meter stick (for measuring shrub and grass/forb heights)
Digital camera, extra camera battery	Photo cards and markers or small dry-erase board and marker
Topographic map with project area, general cover types, and pasture boundaries delineated	Aerial photographs
Ecological Site Guides	GPS unit, compass
Clipboard, data forms and/or data logger with extra battery, pencils	Calculator

Protocol:

- Seasonal habitat has been stratified by land cover types prior to field evaluation (see chapter II for more directions).
- Conduct an appropriate number of transects in each seasonal habitat by each land cover type. Repeat all steps for each transect.

1. Complete all metadata information at the top of the appropriate field forms for each transect, making sure that the plot identification information (i.e., plot number) matches that recorded on the overall plot metadata form. If more than 25 Daubenmire plots are being recorded on a transect, attach additional forms as needed. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names are found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River home range).

   Associated Leks: List the two largest occupied leks to which the breeding habitat is associated. Use identification numbers or names that are used in the statewide database.

   Land Cover Type: Identify the cover type of the data collected. Use plant alliances or associations (Reid et al. 2002) for sagebrush or grassland communities; use www.natureserve.org/explorer (International Classification of Ecological Communities) or other sampling strata to describe the habitat (e.g., percent sagebrush categories). Use the species symbol for dominant species in the overstory and understory (table B-1), for example, ARTRW8 (alliance level – Wyoming big sagebrush) or ARTRW8/FEID (association level – Wyoming big sagebrush/Idaho fescue).

   Ecological Site: Refer to soil maps, range site guides, and ecological site descriptions where available and record the appropriate ecological site. Use the species symbol for dominant species in the overstory and understory.

   Seasonal Habitat: List one of the following: lek, nesting/early brood-rearing, summer/late brood-rearing, or winter.

   Site Info:

   Arid Site: Applies to sagebrush ecological sites generally in the 25-30 cm (~10-12 in) precipitation zone. Wyoming big sagebrush is a common big sagebrush subspecies for this type of site.

   Mesic Site: Applies to sagebrush ecological sites generally in a >30 cm (12 in) precipitation zone. Mountain big sagebrush is a common big sagebrush subspecies for this type of site.

   Transect #: Assign a unique identifier to each transect within the land cover type.

   Area Sampled: Record the total area (indicating ha/ac) or distance for riparian areas (indicating km/mi) of the site type or land cover type sampled.

2. Anchor the tape with a steel pin and pull the tape out 50 meters. Keep the tape as taught and straight as possible. Anchor the tape on the far end. For smaller cover type inclusions or stringers or other unique situations, the transect length may be increased or decreased, as appropriate, to adequately sample the site. This will necessitate modifying the sampling distance for Daubenmire frames along the tape to accommodate 25 frames.

3. Begin at the "0" end of the tape.

4. On the data form, record **shrub cover** by species and subspecies using the line intercept method. Two forms are provided. The electronic version provides an example of data to be collected when using a laptop computer or data logger. The paper version is for collecting data via nonelectronic means.

   a. For the entire length of the line, determine the *intercept length* of any shrub species that touches the line. Only live portions of the shrub canopy are recorded. Intercept length is the portion of the transect length intercepted by the shrub, measured by a perpendicular projection of the shrub foliage over the line (figure B-4).

   b. List all cover increments for each species measured to the nearest 1 cm. Ignore spaces or gaps in the canopy *less than 5 cm* across. Gaps in the live canopy in excess of 5 cm *will not* be included as canopy intercepts (figure B-5). Record only live (leaves, live stems, and shrub trunk) canopy cover.

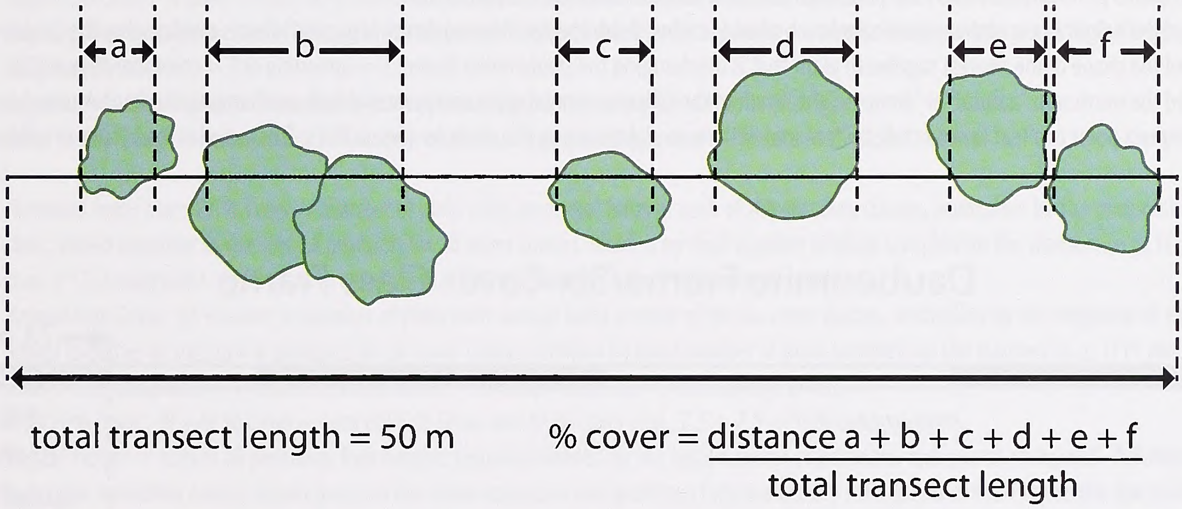

a
b
c
d
e
f
total transect length = 50 m
% cover = distance a + b + c + d + e + f / total transect length

Figure B-4. The line intercept method can be used to measure canopy cover of sagebrush species.

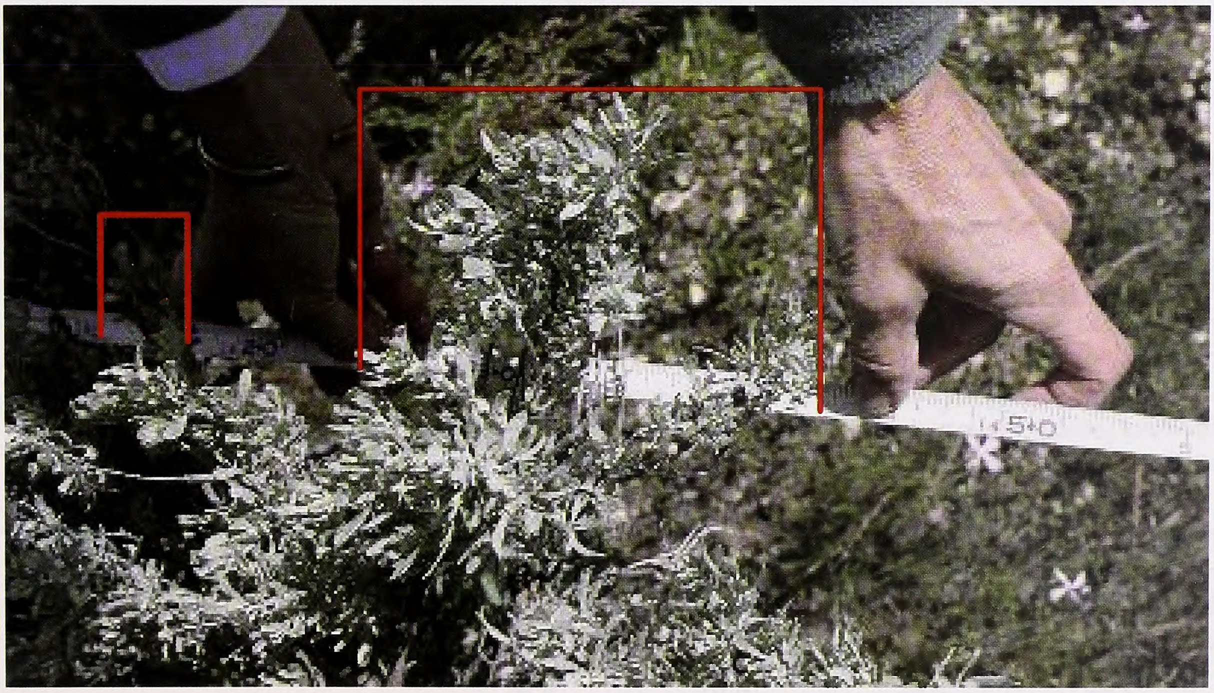


Figure B-5. Measuring shrub canopy cover using the line intercept method. Group sagebrush with gaps smaller than 5 cm. Record sections of sagebrush separated by greater than 5 cm as separate intercepts.

5. Estimate **cover class** and **vegetation height** using the Daubenmire method at each 2-m increment (n = 25 plots per transect) along the tape:

   a. Place a 20 x 50 cm Daubenmire frame (figure B-6) along the tape with the long axis perpendicular to the tape (figure B-7). For each plot, estimate and record cover class for annual forbs, perennial forbs, annual grasses, and perennial grasses by species (based on Connelly et al. 2003):

Cover classes:	1 = 0-5%	midpoint of range 2.5%
	2 = >5-25%	midpoint of range 15%
	3 = >25-50%	midpoint of range 37.5%
	4 = >50-75%	midpoint of range 62.5%
	5 = >75-95%	midpoint of range 85%
	6 = >95-100%	midpoint of range 97.5%

   b. Count plants providing cover over the plot, regardless of if they are rooted in the plot or not.

   c. Record the height in cm of the nearest sagebrush plant (or other shrub species if no sagebrush is present) that is overhanging the Daubenmire frame.

   d. Record the shape of the nearest sagebrush plant that is overhanging the Daubenmire frame: S = spreading or C = columnar (figure 13).

   e. Record the maximum "natural" or "droop height" in cm of the tallest perennial grass and perennial forb overhanging the Daubenmire frame (natural = the highest point of a leaf or seed stalk is measured with no straightening by the observer (figure B-3). This includes seed stalks or inflorescences.

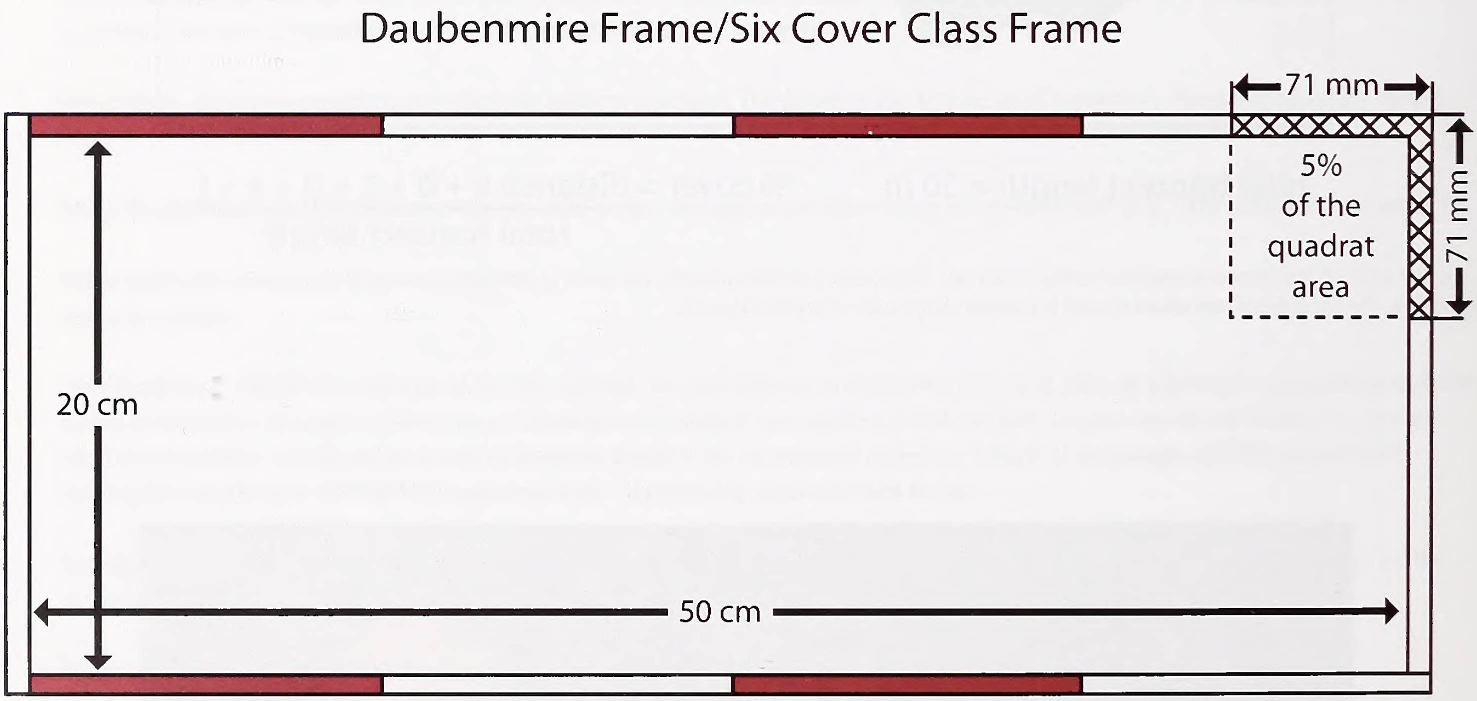


Figure B-6. The Daubenmire frame is used for estimating grass and forb canopy covers. Estimate canopy cover class of species rooted within or overhanging the frame using lines on the frame as guides.

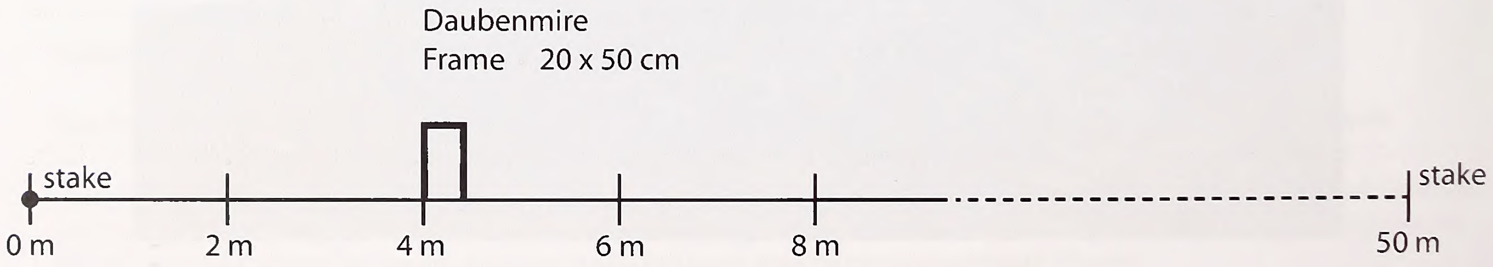


Figure B-7. A line transect with Daubenmire frames positioned every 2 meters.

6. Summarize the data under Line Intercept Shrub Cover:

   a. **Shrub Species:**
      - *Total* = sum of intercept lengths for each shrub species.
      - *% Cover* = total shrub intercept length by species divided by full transect length.

   b. **All Shrubs:**
      - *% Cover* = sum of above % cover calculations by species. The total could exceed 100% if the intercepts of overlapping canopies are recorded.

7. Summarize the data at the top of the form:

   a. **Shrubs:**
      - *Sagebrush Cover: % Cover* = sum of % covers of all sagebrush species listed under Shrub Species in the Cover section.
      - *Avg. Sagebrush Height* = sum of all sagebrush recorded heights divided by total number of sagebrush plants measured in the Vegetation Height section.
      - *Sagebrush Shape* = total # of sagebrush plants of each shape, spreading (S) and columnar (C).
      - *Other Shrub Cover: % Cover* = sum of % covers of all shrub species listed under All Shrubs in the Cover section.

   b. **Forbs:**
      - *Perennial Forb Cover: PF % Cover* = number of plots with perennial forbs in each of the six cover classes, multiplied by the midpoint of each cover class, added together as the sum of products for all cover classes, divided by total number of plots sampled on the transect (e.g., [(15 plots in cover class 1 * 2.5 midpoint) + (10 plots in cover class 2 * 15 midpoint)] / 25 = 7.5% canopy cover).
      - *Annual Forb Cover: AF % Cover* = number of plots with annual forbs in each of the six cover classes, multiplied by the midpoint of each cover class, added together as the sum of products for all cover classes, divided by total number of plots sampled on the transect (e.g., [(15 plots in cover class 1 * 2.5 midpoint) + (10 plots in cover class 2 * 15 midpoint)] / 25 = 7.5% canopy cover).
      - *Total Forb Cover: PF+AF % Cover* = sum of *PF % Cover* and *AF % Cover* (e.g., 7.5 + 7.5 = 15% canopy cover).
      - *Avg. PF Height* = sum of all perennial forb heights recorded divided by the total number of perennial forb plants measured. Relative to perennial forbs, the suitability rating should focus on the cover estimates and preferred forb availability ratings rather than on height due to the variability in heights that can be encountered between forbs and grasses. However, average perennial forb height and/or average perennial forb and grass height (combined) can be calculated, if desired, to provide additional context to the description of the assessment area.

   c. **Grasses:**
      - *Perennial Grass Cover: PG % Cover* = number of plots with perennial grasses in each of the six cover classes, multiplied by the midpoint of each cover class, added together as the sum of products for all cover classes, divided by total number of plots sampled on the transect.
      - *Annual Grass Cover: AG % Cover* = number of plots with annual grasses in each of the six cover classes, multiplied by the midpoint of each cover class, added together as the sum of products for all cover classes, divided by total number of plots sampled on the transect.
      - *Total Grass Cover: PG+AG % Cover* = sum of *PG % cover* and *AG % cover.*
      - *Avg. PG Height* = sum of all perennial grass recorded heights divided by total number of perennial grass plants measured.
      - *Sandberg bluegrass (or similar species)*:

        1. Summarize cover and height for perennial grasses, excluding Sandberg bluegrass, or similar short-statured perennial grasses.
        2. Summarize cover and height for Sandberg bluegrass.
        3. Summarize cover and height inclusive of all perennial grasses.

        Because shorter-statured perennial grasses such as Sandberg bluegrass may influence cover and height averages especially where abundant, the authors recommend that perennial grass metrics be summarized using all three methods to provide additional context for the perennial grass suitability rating. For example, if cover and height for perennial grasses, excluding Sandberg bluegrass (#1), are within the range of the suitable category in the HAF, then consider a ranking of "suitable" for the perennial grass indicator. However, if average cover (regardless of height) of these perennial grasses is not within the suitable category, use the cover and height averages for all perennial grasses, including Sandberg bluegrass (#3). Then, use the cover and height averages for the non-Sandberg perennial grasses (#1), as well as for Sandberg bluegrass itself (#2), to inform the rationale for the rating of the perennial grass indicator. Also, consider the capability of the site to provide species composition, cover, and structure for productive sage-grouse habitat on an annual basis.

8. OPTIONAL: Complete the "Sage-Grouse Forb Diversity Data Form," or use the forb data collected in the Daubenmire frame to compile forb information for the site. Later, write a short narrative describing forb diversity relative to the site.

9. OPTIONAL: Record ground cover at each of the four outside corners of the Daubenmire frame in the four ground cover cells for each plot. See the codes below:

G = gravel (≤5 mm or ~1/4 in)
R = rock (>5mm or ~1/4 in)
BR = bedrock
D = duff (when there is no clear boundary between litter and mineral soil and litter is not removed during typical storms (occurring annually))
M = moss
LC = visible lichen crust on soil
S = soil
L = herbaceous litter (≤5 mm or ~1/4 in; defined as detached stems, roots, and leaves)
WL = woody litter (>5mm or ~1/4 in)
EL = embedded litter (where removal of the litter would leave an indentation in the soil surface or would disturb the soil surface, breaking the soil crust)
V = live vegetation

Sage-Grouse Forb Diversity Data Form

Date: **County:** **State:** **Evaluator(s):**

Population: **Home Range Name:**

Land Cover Type: **Ecological Site:**

Associated Leks: **Seasonal Habitat:**

Transect #: **Site Info. (circle one):** Arid Site Mesic Site

Forb Diversity (see directions)

Type	Species	Forb Plot Number																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	T

Type: P= preferred, N=noxious, I= invasive, O=other. **Note:** The forb type can be determined later in the office or via automated approaches.

Sage-Grouse Forb Diversity Summary Form

Date:	County:	State:	Evaluator(s):
Population:			Home Range Name:
Land Cover Type:			Ecological Site:
Associated Leks:			Transect #:
Area (ha/ac) Sampled:			Site Info. (circle one): Arid Site Mesic Site
Seasonal Habitat:			UTM:
PFC Status (riparian areas only, circle one): PFC FAR NF Unknown			

Transect Data Summary (see directions)

Preferred Forb Species	Noxious Weeds	Invasive Annual Forbs	Other Forbs
Total Species (#): ________ List major species:	Total Species (#): ________ List major species:	Total Species (#): ________ List major species:	Total Species (#): ________ List major species:

Comments (describe the diversity, availability, and relative abundance of preferred forbs in relation to site potential):

Sage-Grouse Forb Diversity Data and Summary Form Directions

Equipment:

Tape, 50 m	Stakes for tape (at least two spikes; old, medium to large screwdrivers work well)
Meter stick (for delineating 180-degree arc)	GPS unit
Pencils, clipboard, and plant identification guide; a local plant species list may be helpful	Calculator

Protocol:

- This worksheet should be used to collect forb availability and diversity information at various breeding and summer habitat sites.
- Forb availability should be evaluated as close to the end of nesting as possible (May-June) to allow for easier identification of plant species, as well as more relevant application to the evaluation of breeding habitat. For low elevation areas, this will be May; for higher elevation areas, it will be June.
- Seasonal habitat has been stratified by land cover types prior to field evaluation (see chapter II for additional discussion).
- Conduct an appropriate number of transects in each seasonal habitat by each land cover type, in association with the LPI transects, as appropriate. Repeat all steps for each transect.
- If a more in-depth, quantitative data collection method (e.g., density or other) is desired by the interdisciplinary team, use the Daubenmire method, by species.

1. Fill out all location information at the top of the sheet (transfer information from the LPI or LIDF data form if used on the same transect line). Be sure to list UTM coordinates or other identifying features of the site. Most of the information should be self-explanatory except the following:

   Population: Identify the population with which the habitat is associated. This definition also includes small populations. Population names can be found in figure 3.

   Home Range Name: Identify the home range area using a major drainage area or other distinguishing land feature (e.g., Little Lost River home range).

   Land Cover Type: Identify the cover type of the data collected:

      Upland Communities: Use plant alliances or associations (Reid et al. 2002) for sagebrush or grassland communities; use www.natureserve.org/explorer (International Classification of Ecological Communities) or other sampling strata used to describe the habitat (e.g., percent sagebrush categories). Use the species symbol for dominant species in the overstory and understory (table B-1), for example, ARTRW8 (alliance level – Wyoming big sagebrush) or ARTRW8/FEID (association level – Wyoming big sagebrush/Idaho fescue).

      Riparian or Wetland Communities: Use site type (riparian areas, wet meadows, springs) or more detailed classification using Cowardin et al. (1979), or riparian type (regional classification systems) to which the data pertain.

   Ecological Site: Refer to soil maps, range site guides, and ecological site descriptions where available, and record the appropriate ecological site. Use the species symbol for dominant species in the overstory and understory.

   Associated Leks: List the two largest occupied leks to which the breeding habitat is associated. Use identification numbers or names that are used in the statewide database.

   Seasonal Habitat: List one of the following: lek, nesting/early brood-rearing, summer/late brood-rearing, or winter.

   Transect #: Assign a unique number to each transect within the land cover type (use the same transect number as for the LPI or LIDF data form).

   Site Info:

      Arid Site: Applies to sagebrush ecological sites generally in the 25-30 cm (10-12 in) precipitation zone. Wyoming big sagebrush is a common big sagebrush subspecies for this type of site.

      Mesic Site: Term applies to sagebrush ecological sites generally in a >30 cm (>12 in) precipitation zone. Mountain big sagebrush is a common big sagebrush subspecies for this type of site.

2. At every 2 meters, record the presence of forbs, by species (in the species column on the form), which are rooted within a 1-meter radius, 180-degree arc, centering on the respective 2-meter mark. Place a check in the box on the form for the appropriate plot if the species is present. See figure B-8 for transect layout.

3. In the office later, or via automated means, annotate the type of forbs encountered as to whether they are preferred (by sage-grouse), noxious, invasive, or other. Invasive forbs are considered of low palatability and ecologically undesirable. Noxious weeds are limited to listed state weeds. Other forbs are any forbs that are not considered to be preferred, noxious, or invasive (e.g., ecologically desirable, but unpalatable forbs such as *Lupinus* spp.) Other forbs may not be preferred by sage-grouse as forage, but may still provide substrate for insects important to young sage-grouse. For preferred forbs, see table B-1.

   a. Calculate the total occurrences by species and sum by forb type (preferred, noxious, invasive, and other) on the "Sage-Grouse Forb Diversity Summary Form." In the comments section of the form, describe, relative to site potential, the general availability, diversity (number of species), and relative abundance of preferred forb species, based on the number of species encountered on the transect and number of plots with preferred forbs. Also discuss other, noxious, and invasive forbs as appropriate. Use professional judgment and augment with other forb information that may have been collected from point intercept or Daubenmire transects.

   b. Use this information to help describe preferred forb availability for breeding and summer habitat evaluations.

4. Provide any additional pertinent information that describes the site in the comments section.

5. Attach this form to the other field data sheet(s) (LPI or LIDF) used for this transect.

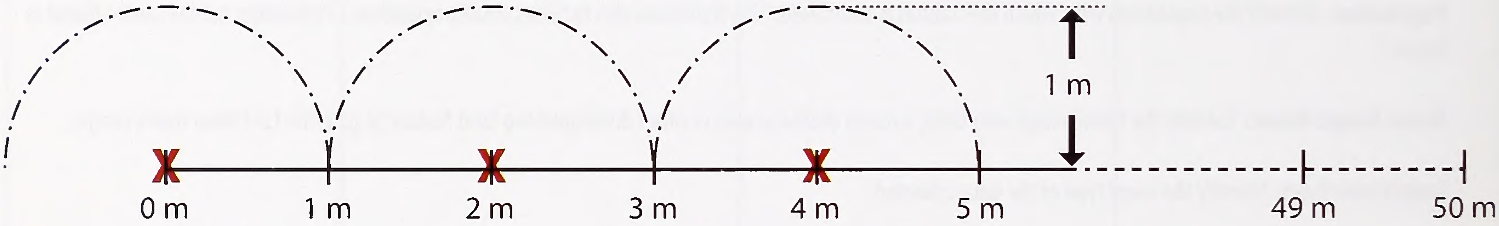


Figure B-8. Forb diversity transect layout. At each 2-m increment, use a 1-m stick to scribe a 180-degree arc. On the "Sage-Grouse Forb Diversity Data Form," record forb species that are rooted within the arc for a total of 25 plots along each transect.

Table B-1. Sagebrush community vegetation species and preferred forbs for sage-grouse. To be used for LPI, LIDF, and forb diversity data collection. Space is provided for the addition of local species. P = preferred forb, W = (noxious) weeds, I = invasive annuals, O = other forbs, N/A = not applicable. Species symbols are current as of 10-01-2013. See the USDA PLANTS database for the most up-to-date species symbols. Other forbs may be palatable at the cotyledon or bud stage.

Scientific Name	Common Name	Symbol	Most Likely Category
SHRUBS			
Dwarf sagebrush			
Artemisia arbuscula	Low sagebrush	ARAR8	N/A
A. arbuscula spp. *longicaulis*	Lahontan sagebrush	ARARL3	N/A
A. arbuscula spp. *longiloba*	Early sagebrush	ARARL	N/A
A. bigelovii	Bigelow sage	ARBI3	N/A
A. nova	Black sagebrush	ARNO4	N/A
A. papposa	Fuzzy sage	ARPA16	N/A
A. pygmaea	Pygmy sagebrush	ARPY2	N/A
A. rigida	Stiff sagebrush	ARRI2	N/A
A. spinescens *Syn = Picrothamnus desertorum*	Bud sagebrush	ARSP5/ PIDE4	N/A
A. tripartita spp. *rupicola*	Wyoming threetip sagebrush	ARTRR2	N/A
Tanacetum nuttallii *Syn = Sphaeromeria argentea*	Silver chickensage	TANU2/ SPAR2	N/A
Tall sagebrush			
A. cana spp. *bolanderi*	Bolander's silver sagebrush	ARCAB3	N/A
A. cana spp. *cana*	Plains silver sagebrush	ARCAC5	N/A
A. cana spp. *viscidula*	Mountain silver sagebrush	ARCAV2	N/A
A. tridentata spp. *spiciformis*	Subalpine big sagebrush	ARTRS2	N/A
A. tridentata spp. *tridentata*	Basin big sagebrush	ARTRT	N/A
A. tridentata spp. *vaseyana*	Mountain big sagebrush	ARTRV	N/A
A. tridentata spp. *wyomingensis*	Wyoming big sagebrush	ARTRW8	N/A
A. tridentata spp. *xericensis*	Xeric big sagebrush	ARTRX	N/A
A. tripartita spp. *tripartita*	Threetip sagebrush	ARTRT2	N/A
Subshrub sagebrush			
A. frigida	Fringed sagewort	ARFR4	N/A
A. pedatifida	Birdfoot sagebrush	ARPE6	N/A
Other shrubs			
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	N/A
Amelanchier utahensis	Utah serviceberry	AMUT	N/A
Atriplex canescens	Fourwing saltbush	ATCA2	N/A
Atriplex confertifolia	Shadscale saltbush	ATCO	N/A
Ceanothus velutinus	Snowbrush ceanothus	CEVE	N/A
Chrysothamnus nauseosus *Syn = Ericameria nauseosa* spp. *nauseosa* var. *nauseosa*	Rubber rabbitbrush	CHNA2/ ERNAN5	N/A
Chrysothamnus viscidiflorus	Green rabbitbrush	CHVI8	N/A
Grayia spinosa	Spiny hopsage	GRSP	N/A
Gutierrezia sarothrae	Broom snakeweed	GUSA2	N/A

Scientific Name	Common Name	Symbol	Most Likely Category
Juniperus occidentalis	Western juniper	JUOC	N/A
Juniperus osteosperma	Utah juniper	JUOS	N/A
Krascheninnikovia lanata	Winterfat	KRLA2	N/A
Pachystima myrsinites	Oregon boxleaf	PAMY2	N/A
Purshia tridentata	Antelope bitterbrush	PUTR2	N/A
Rosa woodsii	Woods' rose	ROWO	N/A
Sarcobatus vermiculatus	Greasewood	SAVE4	N/A
Symphoricarpos albus	Common snowberry	SYAL	N/A
Symphoricarpos oreophilus	Mountain snowberry	SYOR2	N/A
Tetradymia canescens	Spineless horsebrush	TECA2	N/A
FORBS			
Annuals/Occasionally Biennials			
Alyssum desertorum	Desert alyssum	ALDE	I
Asperugo procumbens	German-madwort	ASPR	I
Camelina microcarpa	Littlepod false flax	CAMI2	I
Carthamus tinctorius	Safflower	CATI	W
Chenopodium spp.	Goosefoot	CHENO	P
Chorispora tenella	Purple mustard	CHTE2	W
Collinsia spp.	Blue eyed Mary	COLLI	P
Collomia spp.	Trumpet	COLLO	P
Cryptantha spp.	Cryptantha	CRYPT	O
Descurainia spp.	Tansymustard	DESCU	I
Epilobium spp.	Willowherb	EPILO	O
Eriastrum sparsiflorum	Great Basin woollystar	ERSP3	P
Eriogonum spp.	Buckwheat	ERIOG	P
Erodium cicutarium	Stork's bill	ERCI6	P
Galium aparine	Stickywilly	GAAP2	I
Halogeton glomeratus	Saltlover	HAGL	I
Helianthus annuus	Common sunflower	HEAN3	O
Kochia scoparia	Kochia	KOSC	W
Lactuca serriola	Prickly lettuce	LASE	P
Lappula texana Syn = *Lappula occidentalis* var. *cupulata*	Flatspine stickseed	LATE3/ LAOCC	I
Lepidium spp.	Pepperweed	LEPID	O
Malacothrix spp.	Desertdandelion	MALAC3	P
Medicago spp.	Alfalfa	MEDIC	P
Melilotus officinalis	Yellow sweetclover	MEOF	P
Microsteris spp.	Microsteris (phlox)	MICRO22	P

Scientific Name	Common Name	Symbol	Most Likely Category
Plantago patagonica	Woolly plantain	PLPA2	P
Plectritis macrocera	Longhorn plectritis	PLMA4	P
Polygonum spp.	Knotweed	POLYG4	P
Ranunculus testiculatus Syn = *Ceratocephala testiculata*	Bur buttercup	RATE/ CETE5	W
Salsola kali	Russian thistle	SAKA	W
Sonchus spp.	Sowthistle	SONCH	P
Stephanomeria spp.	Wirelettuce	STEPH	P
Thlaspi arvense	Field pennycress	THAR5	I
Tragopogon spp.	Goatsbeard	TRAGO	P
Trifolium spp.	Clover	TRIFO	P
Veronica spp.	Speedwell	VERON	I
Biennials			
Cirsium spp.	Thistle	CIRSI	W
Cynoglossum officinale	Hound's tongue	CYOF	W
Gilia aggregata Syn = *Ipomopsis aggregata* spp. *aggregata*	Scarlet gilia	GIAG/ IPAGA3	P
Machaeranthera canescens	Hoary aster	MACA2	0
Perennials/Occasionally Biennials			
Achillea millefolium	Common yarrow	ACMI2	0
Agoseris spp.	Agoseris	AGOSE	P
Allium spp.	Onion	ALLIU	P
Androsace septentrionalis	Pygmyflower rockjasmine	ANSE4	P
Antennaria spp.	Pussytoes	ANTEN	0
Arabis holboellii	Holboell's rockcress	ARHO2	P
Arenaria kingii	King's sandwort	ARKI	P
Artemisia dracunculus	Tarragon	ARDR4	P
Aster chilensis Syn = *Symphyotrichum chilense* var. *chilense*	Pacific aster	ASCH2/ SYCHC	P
Astragalus spp.	Milkvetch	ASTRA	P

Scientific Name	Common Name	Symbol	Most Likely Category
Balsamorhiza hookeri	Hooker's balsamroot	BAHO	P
Balsamorhiza sagittata	Arrowleaf balsamroot	BASA3	P
Berberis repens	Creeping barberry	MARE11	O
Brodiaea spp.	Brodiaea	BRODI	P
Calochortus spp.	Mariposa lily	CALOC	P
Camassia spp.	Camas	CAMAS	P
Castilleja spp.	Indian paintbrush	CASTI2	O
Chaenactis douglasii	Douglas's dustymaiden	CHDO	P
Comandra umbellata	Bastard toadflax	COUM	P
Convolvulus arvensis	Field bindweed	COAR4	W
Crepis spp.	Hawksbeard	CREPI	P
Cymopterus spp.	Springparsley	CYMOP2	P
Camassia spp.	Camas	CAMAS	P
Dalea spp.	Prairie clover	DALEA	P
Delphinium nuttallianum	Twolobe larkspur	DENU2	O
Erigeron spp.	Fleabane	ERIGE2	P
Eriogonum spp.	Buckwheat	ERIOG	O
Erysimum spp.	Wallflower	ERYSI	P
Fritillaria spp.	Fritillary	FRITI	P
Geranium viscosissimum	Sticky purple geranium	GEVI2	P
Geum spp.	Avens	GEUM	P
Grindelia squarrosa	Curlycup gumweed	GRSQ	I
Hackelia spp.	Stickseed	HACKE	O
Haplopappus acaulis	Stemless mock goldenweed	HAAC	O
Hedysarum spp.	Sweetvetch	HEDYS	P
Helianthella spp.	Helianthella	HELIA	P
Hydrophyllum capitatum	Ballhead waterleaf	HYCA4	P
Iva axillaris	Povertyweed	IVAX	P
Lathyrus spp.	Pea	LATHY	P
Leptodactylon pungens Syn = *Linanthus pungens*	Granite prickly phlox	LEPU/ LIPU11	P
Linanthus spp.	Linanthus	LINAN2	P
Linum perenne	Blue flax	LIPE2	O
Lithophragma spp.	Woodland-star	LITHO2	P
Lithospermum ruderale	Western stoneseed	LIRU4	P
Lomatium spp.	Desertparsley	LOMAT	P
Lotus corniculatus	Bird's-foot trefoil	LOCO6	P
Lupinus spp.	Lupine	LUPIN	O
Lygodesmia spp.	Skeletonplant	LYGOD	P
Mentha spp.	Mint	MENTH	I
Mentzelia spp.	Blazingstar	MENTZ	P
Mertensia spp.	Bluebells	MERTE	P

Scientific Name	Common Name	Symbol	Most Likely Category
Microseris spp.	Silverpuffs	MICRO6	P
Oenothera spp.	Evening-primrose	OENOT	O
Opuntia polyacantha	Plains pricklypear	OPPO	N/A
Penstemon spp.	Beardtongue	PENST	P
Perideridia spp.	Yampah	PERID	P
Phacelia spp.	Phacelia	PHACE	P
Phlox spp.	Phlox	PHLOX	O
Ranunculus spp.	Buttercup	RANUN	O
Rumex spp.	Dock	RUMEX	O
Sanguisorba minor	Small burnet	SAMI3	P
Sedum spp.	Stonecrop	SEDUM	P
Senecio spp.	Ragwort	SENEC	O
Smilacina racemosa Syn = *Maianthemum racemosum* spp. *racemosum*	Feathery false lily of the valley	SMRA/ MARAR	P
Solidago spp.	Goldenrod	SOLID	P
Sphaeralcea spp.	Globemallow	SPHAE	P
Taraxacum officinale	Common dandelion	TAOF	P
Townsendia hookeri	Hooker's Townsend daisy	TOHO	P
Vicia spp.	Vetch	VICIA	P
Viola nuttallii	Nuttall's violet	VINU2	O
Viola purpurea	Goosefoot violet	VIPU4	O
Wyethia amplexicaulis	Mule-ears	WYAM	O
Zigadenus spp.	Deathcamas	ZIGAD	O
GRASSES			
Annuals			
Avena fatua	Wild oat	AVFA	N/A
Bromus commutatus Syn = *Bromus racemosus*	Bald brome	BRCO4/ BRRA2	N/A
Bromus japonicus	Japanese brome	BRJA	N/A
Bromus mollis Syn = *Bromus hordeaceus* spp. *hordeaceus*	Soft brome	BRMO2/ BRHOH	N/A
Bromus tectorum	Cheatgrass	BRTE	N/A
Festuca octoflora	Sixweeks fescue	FEOC3	N/A
Triticum aestivum	Common wheat	TRAE	N/A

Scientific Name	Common Name	Symbol	Most Likely Category
Perennials			
Achnatherum thurberianum	Thurber's needlegrass	ACTH7/ STTH2	N/A
Agropyron cristatum	Crested wheatgrass	AGCR	N/A
Agropyron intermedium Syn = *Thinopyrum intermedium*	Intermediate wheatgrass	AGIN2/ THIN	N/A
Agropyron repens Syn = *Elymus repens*	Quackgrass	AGRE2/ ELRE4	N/A
Agropyron smithii Syn = *Pascopyrum smithii*	Western wheatgrass	AGSM/ PASM	N/A
Agropyron spicatum Syn = *Pseudoroegneria spicata* spp. *spicata*	Bluebunch wheatgrass	AGSP/ PSSPS	N/A
Bromus inermis	Smooth brome	BRIN2	N/A
Carex douglasii	Douglas' sedge	CADO2	N/A
Elymus cinereus Syn = *Leymus cinereus*	Basin wildrye	ELCI2/ LECI4	N/A
Elymus junceus Syn = *Psathyrostachys juncea*	Russian wildrye	ELJU/ PSJU3	N/A
Festuca idahoensis	Idaho fescue	FEID	N/A
Koeleria cristata Syn = *Koeleria macrantha*	Prairie junegrass	KOCR/ KOMA	N/A
Melica bulbosa	Oniongrass	MEBU	N/A
Oryzopsis hymenoides Syn = *Achnatherum hymenoides*	Indian ricegrass	ORHY/ ACHY	N/A
Poa bulbosa	Bulbous bluegrass	POBU	N/A
Poa juncifolia Syn = *Poa secunda*	Sandberg bluegrass	POJU/ POSE	N/A
Poa sandbergii Syn = *Poa secunda*	Sandberg bluegrass	POSA12/ POSE	N/A
Poa scabrella Syn = *Poa secunda*	Sandberg bluegrass	POSC/ POSE	N/A
Sitanion hystrix Syn = *Elymus elymoides* spp. *elymoides*	Squirreltail	SIHY/ ELELE	N/A
Stipa comata Syn = *Hesperostipa comata* spp. *comata*	Needle and thread	STCO4/ HECOC8	N/A
Stipa occidentalis Syn = *Achnatherum occidentale* spp. *occidentale*	Western needlegrass	STOC2/ ACOCO	N/A

SEDGES			
Typha spp.	Cattail	TYPHA	N/A